NOTICE

All drawings located at the end of the document.

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TECHNICAL MEMORANDUM

REVISED FIELD SAMPLING PLAN
AND DATA QUALITY OBJECTIVES

THE WEST SPRAY FIELD (IHSS 168)
OPERABLE UNIT NO. 11

FINAL
REVISION 0

ROCKY FLATS PLANT

U. S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

ENVIRONMENTAL RESTORATION MANAGEMENT
June 13, 1994

RFI/RI WORK PLAN TECHNICAL MEMORANDUM
APPROVAL SHEET

EG&G ROCKY FLATS PLANT

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TITLE:

TECHNICAL MEMORANDUM Revised Field Sampling Plan and Data Quality Objectives
The West Spray Field (IHSS 168) Operable Unit 11

Approved By:

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EXECUTIVE SUMMARY

This Technical Memorandum (TM) presents the Revised Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Field Sampling Plan (FSP) and Data Quality Objectives (DQOs) for Operable Unit 11 (OU 11), West Spray Field (WSF). This FSP refines and focuses the scope of work for the investigation originally presented in the OU 11 Phase I RFI/RI Work Plan (EG&G 1992a). The justification for proposing this revised FSP is based upon 1) A review of historical data collected for the WSF, 2) recent information obtained from a radiation screening survey and 3) current groundwater monitoring activities. Most of this data and analysis was not available during the development of the original OU 11 Work Plan.

OU 11 is classified as a RCRA lead OU in the Interagency Agreement (IAG). As a result of this classification, OU 11 originally was planned to be investigated in two separate phases. These phases are defined in Attachment 2, Section I.B.11.b of the IAG. During the initial phase, the nature and extent of contamination within the "source and soil" would be investigated. In the next phase, the "nature and extent" of contamination that may have the potential to migrate outside the boundaries of the OU would have been investigated. This revised FSP proposes to combine both phases of the investigation and subsequent reporting.

RCRA Subpart G Part 265.111(b) and the Colorado Hazardous Waste Act (CHWA, 6CCR1007) requires a closure performance standard that "controls, minimizes, or eliminates [contamination] to the extent necessary to protect human health and the environment". Compliance with this requirement is demonstrated by controls that can be established to mitigate any identified risk. Typically, this risk assessment process is divided into two separate assessments since the data necessary to determine risk from all potential pathways (i.e. groundwater, air, etc.) is provided by two separate field investigations. The Phase I risk assessment evaluates risk from the "upward pathways" (i.e. exposure by air transport of contaminants or direct contact with contaminants). Phase II would evaluate exposure from contaminated groundwater or surface water.

The objective of this revised FSP is to acquire data to determine if potential sources exist within OU 11 that might present a risk to human health or the environment as required. However, this revised FSP proposes that activities from the Phase I Investigation be combined with the Phase II investigation activities. Combining these phases will allow an early comprehensive assessment of risk and will provide data for public presentation several years ahead of the original IAG schedule. The proposed process for investigation and evaluation of risk at OU 11 is represented in Figure ES-1.

The fieldwork proposed consists of:

- Vadose zone investigations (includes borehole sampling and monitoring well installation) to assess the nature and extent of potential contamination and to assess the viability of this medium as a contaminant transport pathway or source and;

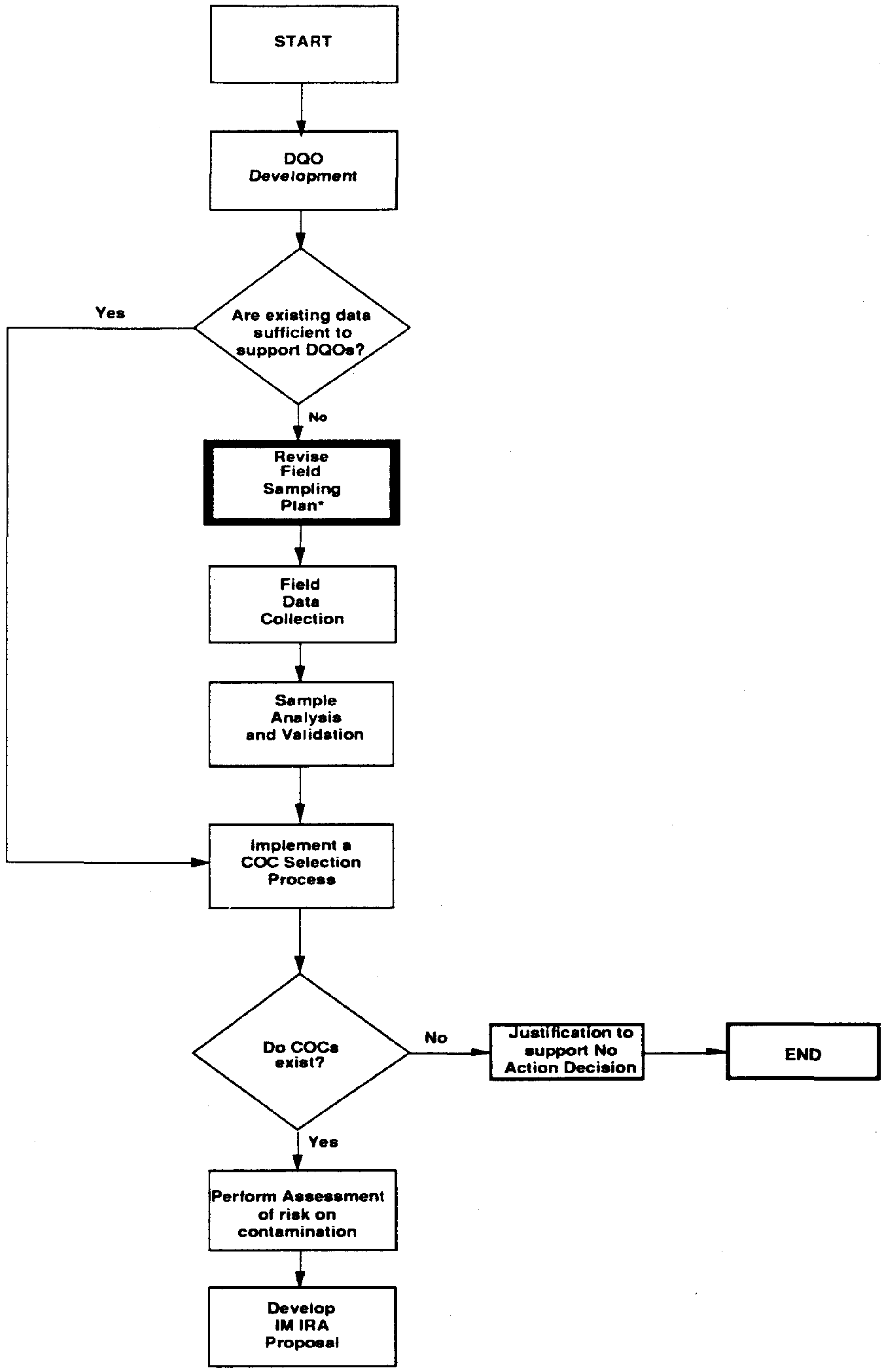
- A surficial soil sampling program to verify HPGe results and determine if levels of contamination that would be of risk to human health and the environment exist at OU 11.

Fieldwork that has already been accomplished in accordance with the original OU 11 Work Plan (EG&G 1992a) consists of;

- Ecological field sampling, including surveys to support a statistical evaluation of the potential for impacts to the ecology;

- A focused High Purity Germanium (HPGe) field screen for potential radiological contamination on the surface.

FIGURE ES-1 OU 11 PROCESS FLOW DIAGRAM



***Highlighted box indicates current stage of the OU 11 process.**

1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE

Purpose

The purpose of this Technical Memorandum (TM) is to provide support for and presentation of a field program that integrates the Phase I and II RFI/RI field investigations for OU 11. The purpose of an RFI/RI field investigation is to determine the risk to human health and the environment, and to define and justify a final action. For the WSF, it is believed that the most efficient method to determine risk and the actions necessary to alleviate those risks is to:

- streamline the Phase I and II field investigations into a single comprehensive effort, and;
- focus the investigation on those areas and media of the WSF where data is lacking.

This approach will eliminate the need for interim studies and investigations, and is based upon a thorough examination of existing data from recent, ongoing, and historical studies (presented in Section 3 of this TM). Historical data was used to the fullest extent in support of this effort. Preliminary and screening data have been gathered to supplement historical data where feasible.

Scope

The scope of this TM consists of the following tasks:

- establish goals for the FSP (Section 2);
- evaluate existing data to determine where further investigation is necessary (Section 3), and;
- propose a revised scope for the OU 11 field investigation Section 4;

Justification for the revised field investigation is provided throughout Sections 3 and 4.

As stated above, the objective of this TM is to evaluate existing field data, to determine the information needed to meet RFI/RI sampling requirements, and to recommend a streamlined approach for completing future field investigations. In order to accomplish this objective, Data

Quality Objectives (DQOs) will first be outlined in order to establish goals for the FSP. DQOs are quantitative and qualitative statements established to ensure that the type, quality and quantity of the data obtained from the investigation are appropriate for the purpose of the project. Data from preliminary screening and historical investigations will then be assessed for its applicability. Preliminary screening data includes surficial radiological surveys to determine personal protective equipment levels, and historical data includes all previous investigations at the WSF, including groundwater monitoring, surficial soil sampling, well logs, aerial photos, etc. Finally, the FSP will be presented based upon the DQOs and existing data.

1.2 BACKGROUND

As part of the Rocky Flats Environmental Restoration program, a multiple-phased RFI/RI is required to investigate the nature and extent of potential contamination at OU 11, the WSF. Phase I would investigate the nature and extent of contamination within the "source and soils". Phase II would typically investigate the nature and extent of contamination from OU 11, which has been interpreted as defining any contamination that may have migrated outside the boundaries of the WSF.

The WSF is located on the west side of the Rocky Flats Plant (RFP) and covers an area of approximately 105.1 acres. Between April 1982 and October 1985, three areas of the WSF were used for periodic spray application of excess liquids pumped from the Solar Evaporation Ponds 207-B North and 207-B Center. Pond 207-B Center was a repository for effluent from the Sewage Treatment Plan (STP). The STP processes sanitary waste from the plant. Pond 207-B North was a repository for water from the interceptor trench system (ITS). The ITS was installed to collect groundwater and seepage from the hillside north of the Solar Evaporation Ponds and water from the Building 771 and 774 footing drains.

The approximate combined spray area for all three lines was 41.3 acres. Area 1 was approximately 35.6 acres in size and accommodated three fixed spray lines (two were previously portable lines) with a width of 80 feet and an average length of 1,524 feet. Area 2 covered approximately 2.5 acres and accommodated a single fixed irrigation line. A spray impulse cannon with a maximum spray radius of 100 feet was used on an east-west trend in

Area 3 (3.2 acres). Figure 1-1 illustrates the three areas of spray application.

Total volumes of Solar Pond water applied between April 1982 and October 1985, and the estimated areas of application for Areas 1, 2, and 3, were used to estimate the amount of water applied from each source. It is estimated that 40 inches of water from Pond 207-B North was applied in Area 1, and 150 inches of water from Pond 207-B Center was applied in Areas 1, 2, and 3. Because liquids from both ponds were applied to Area 1, the maximum total application could have been as much as 190 inches over the 8.4 acre area for all four years of application (approximately 66,000,000 gallons).

2.0 DATA QUALITY OBJECTIVES

The U. S. Environmental Protection Agency (EPA) has established a 7-step process to SUPERFUND decision-making as the basis for developing DQOs (EPA, 1993a). DQOs are quantitative and qualitative statements that are established to ensure that the type, quality and quantity of the data are optimized for accomplishing the purpose of the project. The DQOs will;

1. clarify the study objective;
2. define the most appropriate type of data to collect;
3. determine the most appropriate conditions from which to collect the data, and;
4. specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision (EPA, 1993a).

For the OU 11 project, the intended use of the data includes human health and ecological risk assessment. Analytical results will be compared with background RFP values, risk-based calculations, and Applicable or Relevant and Appropriate Requirements (ARARs). If required, the data will also be the basis for corrective measure design. In addition, precision, accuracy, representativeness, comparability, and completeness (PARCC) are DQOs set forth in the EPA Guidelines (EPA, 1987), DOE Data Management Requirements (DOE, 1993), and the Quality Assurance Project Plan (QAPjP) (EG&G, 1992b).

2.1 Data Quality Objectives Process

The DQO process is a series of planning steps based on the scientific method that is designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate for the intended application (EPA, 1993a). The DQOs are statements derived from an iterative 7-step process that streamlines the study so that only those data needed to make a decision are collected and used. The process consists of the following seven steps:

1. State the Problem
2. Identify the Decision
3. Identify Inputs to the Decision
4. Define the Study Boundaries
5. Develop a Decision Rule
6. Specify Limits on Decision Errors
7. Optimize the Design for Obtaining Data

Step 1: State the Problem

The WSF at the RFP has been exposed to waters originating from the ITS and the Solar Evaporation Ponds and, with process knowledge, the risk to human health and the environment is unknown and must be determined. Possible contamination is from radionuclides, metals, and major anions. A hydrogeologic conceptual site model was developed for the OU and is presented in detail in this section. Due to the lack of data concerning groundwater in the upper portion of the upper hydrostratigraphic unit (Figure 2-1), this media will be one of the primary concerns of the OU 11 investigation presented in this FSP. Media of concern also include surface and subsurface soils.

Several types of environmental specialists are needed to implement the DQO process. The planning team consists of a project manager and lead, a hydrogeologist, two statisticians, at least three risk assessors, a geologic engineer, quality assurance personnel, and two biologists. The primary decision makers consist of representatives from the Colorado Department of Health (CDH), EPA, DOE and EG&G Project Management for OU 11.

Conceptual Site Model

The function of the WSF conceptual model is to describe the site and its environs and to present hypotheses regarding contamination (or potential contamination), routes of migration, and potential impact on receptors. The original Phase I RFI/RI Work Plan for OU 11 presented a conceptual model that included a description of the contaminant source, release mechanisms, transport medium, contaminant migration pathways, exposure routes, and receptors. The Hydrogeologic Conceptual Model (Figure 2-1) takes the modeling process one step further by presenting potential migration pathways in a geologic setting. The primary release mechanisms for contaminants from the WSF are fugitive dust, surface-water runoff, infiltration and percolation of groundwater, bioconcentration/bioaccumulation, and tracking. The possible exposure pathways for contaminants resulting from spray application include ingestion, inhalation, and dermal contact of the contaminated soil, groundwater, and/or surface water.

Surficial and shallow soils, which received waste water through direct application and surface runoff, are recognized as media of concern for potential contamination. However, historical analytical results show most contaminant concentrations in these media are below background levels (Section 3.3). Soil characterization activities and recommendations relative to previously collected data are presented in Sections 3.0 (Summary of Existing Data) and 4.0 (Sampling and Analysis Plan) of this TM.

The upper portion of the upper hydrostratigraphic unit has not been thoroughly investigated. The media of concern that received the most attention historically were shallow soils, surface soils, and the saturated zone (the lower portion of the upper hydrostratigraphic unit). Relatively little attention has been given to potential perched water zones resulting from spray application. This perched system is thought to exist for the following three reasons;

1. <u>Historical Monitoring Data</u>

The following wells were drilled for the purpose of monitoring shallow groundwater in the unsaturated zone: 1081, 0782, 0582, and 0682. RFEDS contains water level data collected quarterly from January, 1987, through July, 1992. These monitoring data demonstrate that the measured depth to water in all wells was around 20 feet, approximately 40 feet above the saturated zone water table. Well data show that the depth to perched water has increased with time following the period of spray application. For example, water level measurements for well 1081 indicate that the depth to water in July, 1987 was 17.3 feet; whereas the depth to water in July, 1992 was 22.6 feet.

From available water-level data we cannot determine perched zone thicknesses, because well completion details and lithologic data are not available. We can observe that the thickness of the perched zone has systematically decreased following spray application.

Nitrate/nitrite RFEDS chemical data for the above referenced wells are mostly not validated, however they demonstrate that initial high concentrations of nitrate/nitrite dissipated quickly following spray application. The table below lists some of the data from two different locations in and near OU11.

Well 1081	Nitrate/Nitrite Concentrations
August, 1986	22.1 mg/l
August, 1987	7.8 mg/l
July, 1991	4.4 mg/l -- (validated)
April, 1992	2.7 mg/l -- (validated)

Well 0682	Nitrate/Nitrite Concentrations
August, 1986	22.1 mg/l
August, 1987	0.28 mg/l
August, 1991	0.3 mg/l -- (validated)

Data supports that nitrate/nitrite concentrations in perched ground waters at these two OU11 locations are relatively insignificant; however these perched conditions are not under the areas that received maximum spray application. The purpose of the Revised Field Sampling Plan is to evaluate contamination concentrations under the areas which received maximum spray application. If perched conditions are not present there, then concerns relative to groundwater contamination are relatively minor.

2. Soil Moisture Encountered During Drilling

In 1992, wells 1081, 0782, 0582, and 0682 were abandoned as part of the Well Abandonment and Replacement Program (WARP). Replacement wells, 46192 and 46292, were drilled utilizing air-fluid percussion technology. Moisture characteristics of the well cuttings exhibited vertical variations consistent with perched groundwater conditions.

3. **Elevated nitrate levels in wells screened throughout the uppermost hydrostratigraphic interval.**

As stated on page 4-4 of the sampling plan, screened intervals of wells in the current monitoring system are either too deep to monitor perched conditions or are screened through the entire thickness of the Rocky Flats Alluvium. Three wells with extensive screened intervals (from near surface to the base of the uppermost hydrostratigraphic unit) include: 4986, 5186, and B410789. During the past several years, nitrate/nitrite has been detected in all three wells at concentrations higher than the sample mean. These concentrations range from approximately 3 to 8 mg/l, whereas the sample mean is 1.7. The interpretation that elevated concentrations are the result of contributing shallow perched waters to the overall groundwater system is reasonable. Perched water zones would have a greater potential of retaining contamination than the lower portion of the upper hydrostratigraphic unit due to the proximity of spraying operations. Therefore, the potential for a perched water system to exist and accumulate contaminants will be investigated.

Hydrogeologic Conceptual Model

The goal of the FSP is to collect data so that the potential of risk from current contamination levels can be determined. Previous soil and groundwater investigations do not indicate that significant levels of contamination exist in OU 11 (Appendix C). Data collected from wells constructed to evaluate only the saturated zone of the uppermost hydrostratigraphic unit indicate that concentrations for individual contaminants are insignificant. However, elevated levels of some contaminants, specifically nitrates, have been detected in wells which were screened to evaluate the entire (saturated and unsaturated) uppermost hydrostratigraphic unit at OU 11 (Figure 2-2). It is hypothesized that these elevated levels are the result of the contribution of contaminated perched groundwater mounds to the overall shallow groundwater system (evidence for perched groundwater conditions is further discussed in Section 4.5). To date, characterization of shallow subsurface lithologies and water chemistries is incomplete.

At the WSF, the uppermost hydrostratigraphic unit is the Rocky Flats Alluvium (RFA), a heterogeneous alluvial fan deposit consisting of unconsolidated gravels, sands, and clays with the water table at a depth of approximately 50 feet. As previously discussed, the probable existence of perched water in the vadose zone is of primary concern for potential groundwater contamination.

Figure 2-1 is a conceptual model for shallow groundwater mounding, which is proposed as a hypothesis to be evaluated. Spray application of water occurred during several years as a waste management activity. Surface runoff, evapotranspiration, and infiltration occurred during that time, and infiltrated water recharged the alluvial hydrostratigraphic unit to a small extent. In addition, water may have accumulated over semi-pervious clay layers or lenses of lower vertical hydraulic conductivity. Finally, when spraying ceased, the amount of water that was perched began to diminish due to continued downward migration and evapotranspiration. If contaminants were present, they may still exist in these perched zones either as dissolved constituents or precipitates.

As explained above, historical water level data and recent drilling reports indicate that perched water conditions may exist under portions of OU 11. Evidence for perched conditions is discussed in detail Section 4.5 where justification of monitoring well locations is also presented. If groundwater has become contaminated to significant levels above background because of spray application, perched water, by virtue of its proximity to the surface of application, would have the potential for containing elevated levels of contamination. The migration of contaminated perched groundwater could constitute a potential health risk. To date, the characterization of vadose zone geology and water chemistry is incomplete. As previously mentioned, most monitoring wells in the WSF were designed to monitor the saturated zone of the uppermost hydrostratigraphic unit. In addition, because of the presence of large cobbles and boulders in the alluvial gravels, most of these wells were drilled using percussion technology. Lithologic descriptions of the collected cuttings lack accuracy and detail. Therefore, for this investigation, subsurface lithologies, as well as borehole and groundwater chemistries will be characterized (in accordance with Section 4.6, Analytical Requirements). Seismic data were not utilized for the selection of the drill sites. However lithologic data collected from the FSP will be used as an aid in calibrating the seismic data to the subsurface geology.

Mathematical Modeling of Perched Groundwater Mounds

For preliminary planning purposes, mathematical analytical modeling was performed. Using a method documented by Brock (Brock, 1976), a hypothetical two dimensional mound profile under WSF Area 1 was developed. Appendix B shows the model calculations used to predict mound height and extent. Parameters used in the model were in accordance with field data collected in other areas of RFP and professional judgement. Hydrologic assumptions relevant to the model are similar to those inherent in various groundwater models and are explicitly stated. This model was specifically used to provide a rough "order-of-magnitude" analysis of anticipated perched groundwater mound height. Modeling results suggest that perched mounds resulting from spray application would be relatively thin, with the calculated steady state mound height under Spray Area 1 being approximately seven feet.

Step 2: Identify the Decision

The Decision

A decision will be made as to whether the concentrations of the potential contaminants of concern are a risk to human health and the environment. The analytical data that exceed background concentrations, ARARs, or Preliminary Remediation Goals (PRGs), will warrant further assessment and/or a response action.

Actions as a result of the resolution of the decision:

A decision of no action is required if Potential Contaminant of Concern (PCOCs) for each medium individually do not exceed background values, ARARs or PRGs. Further assessment and/or a response action will be conducted if action levels are exceeded. For example, if levels of contamination are found that exceed threshold values, then further vadose zone characterization will be considered for analysis of the migration of contaminated groundwater as a source of significant risk. If no perched water mounds are found or if levels of contamination are found below threshold values in shallow perched groundwater mounds, then no further characterization of the groundwater system will be deemed necessary.

Step 3: Identify the Inputs to the Decision

Information that will be required to make the decision:

All historical analytical data collected from the 1988 test pits sampling, historical and current monitoring well activities, and process knowledge of the Solar Evaporation Ponds (quantitative and qualitative) will be compiled to identify the areal extent of contamination in order to determine the sample variance and sample mean of analytes from each media sampled over time at the WSF.

To assess risk, this investigation will also include the examination of:

- Groundwater flowpaths and hydraulic gradients of the upper aquifer.
- Water levels, potentiometric surface, hydraulic gradient and potential clay lenses from previously installed wells.
- Hydrological modeling input and out-put data to further identify the presence and extent of the perched water mounds that are indicative of the site.

Information needed to identify the action level:

The action levels of the PCOCs will be determined by the regulatory agencies and will include consideration of background values, ARARs and PRGs.

The appropriate sampling techniques and analytical methods used to obtain the data:

EPA-approved field sampling techniques for sub-surface soil sampling, monitoring well installation, and groundwater sampling are listed in Section 4.5 of this TM. The associated analytical parameters that will be used for the sampling are listed in Section 4.6 of this TM. The analytical methods for each parameter are listed in Appendix B of the QAPjP (EG&G, 1992b). Table 2-1 summarizes the objectives, activities, uses, and analytical levels for this investigation.

Table 2-1

OBJECTIVES AND ACTIVITIES OF THE REVISED FIELD SAMPLING PLAN

Objective	Activity	Data Type	Data Use
Determine if contamination exists in the Vadose Zone	1) Collect and analyze soil samples from borehole core	FIELD QUANTITATIVE	Site characterization Risk assessment Field decisions
	2) Install monitoring wells to collect and analyze perched groundwater if appropriate	FIELD QUANTITATIVE	
	3) Drill to saturated zone if perched water does not exist.	FIELD	
Determine if contamination exists in surface soils	1) Obtain recent HPGe survey data and 1989 aerial gamma survey data	QUANTITATIVE	Site characterization Risk assessment Health and safety
	2) Collect and analyze surface soil samples	FIELD QUANTITATIVE	
Assess current ecological conditions	1) Compare current conditions to background	QUANTITATIVE	Site characterization Risk Assessment
	2) Determine the absence or presence of adverse impacts to the ecology	FIELD QUANTITATIVE	

Step 4: Boundaries

Spatial boundaries:

The investigation of OU 11 (IHSS 168) will focus on surface soils, sub-surface soils, and groundwater from perched groundwater mounds. Sub-surface soil sampling will extend to the saturated zone and samples will be collected at two foot intervals (the upper five feet of the vadose zone is of particular interest). Groundwater will be sampled from monitoring wells finished in the boreholes.

Characteristics that will define the population of interest:

The PCOCs for the baseline risk assessment, which are yet to be determined, will focus on surface soils, sub-surface soils, and groundwater. The data collected will be compared to the established background analyte levels, relevant ARARs and PRGs.

The scale of decision making:

Samples will be collected from surficial soils, subsurface soils (soil boreholes), and perched water mounds. Separate decisions will be made for surface soils, each identified perched water mound, and the associated sub-surface soil and clay layers.

Temporal boundaries:

In 1986 and 1988, soils studies showed that surface soils in the WSF do not pose an immediate threat to human health or the environment. Similarly, no threat is indicated from RCRA groundwater monitoring, which has been conducted since 1988. Field work on OU 11 will begin as soon as the FSP is approved and is expected to take approximately one month. Since the FSP combines the Phase I and Phase II programs for OU 11, the activities will be tightly focused, and an RFI/RI report will be completed several years ahead of the original IAG schedule.

Practical constraints on the data collection:

The most important possible constraint on data collection is the ability to penetrate the RFA for thorough sample collection. Because the RFA is heterogeneous alluvial material, standard drilling methods have proven inadequate for sample collection. Use of a sonic drilling rig is proposed for future work, as it has worked well for other investigations in similar geologic materials.

Step 5: Develop a Decision Rule

Parameters that characterize the population of interest:

PCOC concentrations will be specified as a characteristic or attribute with regards to minimum, maximum, mean, and/or as a variance that is relevant for each of the sampled media that will be compared to the pertinent threshold value.

Action levels for the study:

PCOC identification will be based upon comparisons to background using the Gilbert test methodology (Gilbert 1993). Analytes identified as being elevated with respect to background will be considered PCOCs.

Action levels for PCOCs will be ARARs or PRGs.

The decision rule for each population of interest:

If the levels of contamination for each environmental media investigated are above threshold levels for the specific contaminants, then the media will be evaluated for further investigation and possible remediation.

Step 6: Specify Limits on Decision Errors

Decision error rates are based on consideration of the consequences of making incorrect decisions. Decision error rates are used to establish appropriate performance goals for limiting uncertainty. Establishing acceptable error rates is necessary prior to determining the appropriate performance goals for limiting uncertainty. Establishing acceptable error rates is necessary prior to determining the appropriate number of data (samples or tests) necessary to support the decision with a specified level of confidence given potential effects on cost, schedule, resource expenditure, human health, and ecological conditions (EPA 1993c).

Type I errors (false positive) occur when the null hypothesis is incorrectly rejected. This occurs when a statistical test determines that significant contamination occurs at OU 11 when it actually does not. Type II errors (false negatives) occur when the null hypothesis is incorrectly accepted. This occurs when a statistical test determines that significant contamination does not exist at OU 11 when it actually does. The power of a statistical test is defined as one minus the Type II error and is the ability of the test to correctly reject the null hypothesis when it is false.

Probability values assigned to Type I and Type II error rates where chosen to reflect the acceptable probability for the occurrence of decision errors. These were chosen as 20 percent for the false positive decision error (Type I error) and 5 percent for the false negative decision error (Type II error). This results in a statistical power of 0.95 to correctly reject the null hypothesis when it is false. A more detailed discussion of error rates and statistical assumptions is presented in Appendix E.

Step 7: Optimize the Design

Each media has a sampling plan designed to reduce decisions errors as much as possible. For surface soil sampling, a biased approach based upon areas of highest spray and possible runoff is utilized and is presented in Section 4.3. Sample size calculations for surficial soils are presented in Appendix E. For subsurface soils and groundwater, error is reduced by using data from previously installed wells in order to determine likely locations of perched water (logic for this assumption is presented in Section 4.0). Constituents for investigation are determined based on past investigations at the WSF, current groundwater monitoring data, and Solar Pond water process knowledge.

2.2 Establishing the PARCC Parameters

The DQO process takes into account the validation of the sampling effort that is used to identify contaminants of concern (COCs). The process of collecting data and analyzing it to obtain usable, quality data that is defensible with respect to the actions taken at a site are based upon the PARCC of the data. These primary analytical DQOs will be used to ensure that the data collected at OU 11 depicts the contaminant levels and the environmental conditions at the time of sampling. Details on the calculations pertaining to PARCC are provided in Section 5.

<u>Precision</u>

Analytical precision is expressed as a percentage of the difference between the results of duplicate samples for a given compound. The Relative Percent Difference (RPD) for water samples will be 30% and for soils will be 40%. The overall required percentage of samples to fall within the DQOs stated, per media and analytical suite, is 85%.

Accuracy

Accuracy will be expressed in terms of completeness and bias. Accuracy is a quantitative measure of data quality that refers to the degree of difference between measured or calculated values and the true value. The closer to the true value, the more accurate the measurement. One of the measures of analytical accuracy is expressed as a percent recovery of a spike or tracer that has been added to the environmental sample at a known concentration before analysis (EG&G, 1991). Although it is not feasible to totally eliminate sources of error that may reduce accuracy, error will be minimized by using standardized analytical methods and field procedures.

In addition, the accuracy of each instrument used that ultimately influences project decisions will be stated. The correct resolution of reported results, and corresponding number of significant figures will be determined, and all of the corresponding measurements (or calculation results, e.g., numerical model output) will be reported consistently. This determination will be based on detection limits; for example, from General Radiochemistry and Routine Analytical Protocol (GRRASP) (EG&G, 1990) specifications, manufacturer's specifications, standard operating procedures, and or instrument-specific calibration data.

Representativeness

Representativeness will be maximized by ensuring that sampling point locations are selected properly, potential "Hot Spots" are addressed, and a sufficient number of samples are collected over a specified time span. All sampling will be conducted as outlined per this FSP and RFP Standard Operating Procedures (SOPs).

Completeness

The amount of usable data collected from the sampling program for all media will be calculated to ensure that the program meets the performance objectives for the study. The goal for completeness is 100% with a minimum acceptance of 90%.

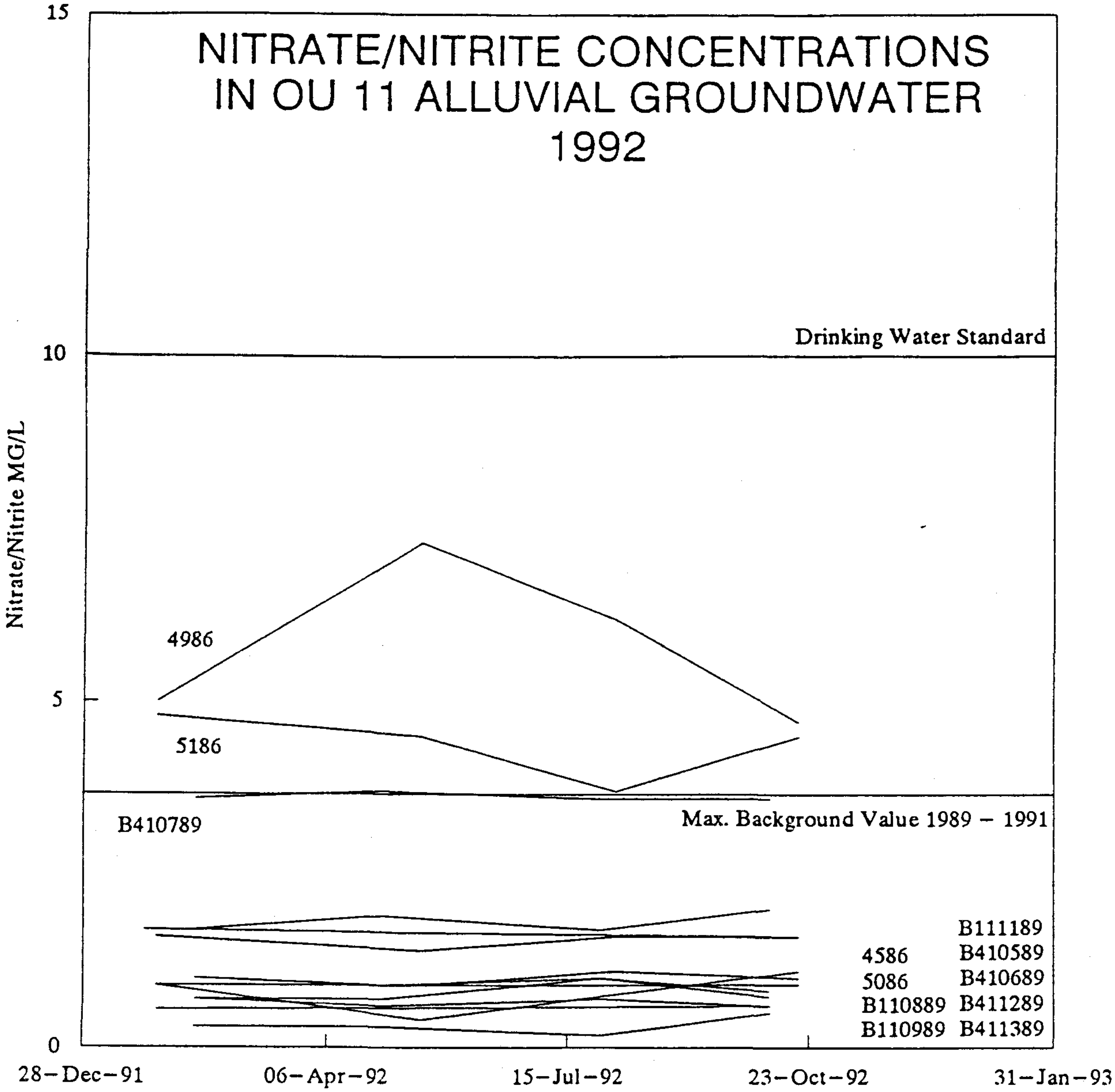
Comparability

Sample data will be comparable with other measurements for similar samples (matrix types) and conditions. The goal for comparability will be achieved by implementing sampling techniques and analytical methods outlined in the SOPs and reporting the results in appropriate units. Comparability will only be performed with confidence when precision and accuracy are known and will be performed with respect to one or more of the following:

1. protocols (e.g., SOPs) used to collect and/or synthesize the samples
2. matrix types (e.g., dry soil samples may not be comparable to saturated soil samples for "fate and transport" purposes)
3. temporal considerations (periodical, seasonal, event-related, etc.)
4. spatial considerations (3-dimensional)

Data set comparison will (at least) include the comparison of real samples with:

1. other real samples, as appropriate; and,
2. background data.



Note: Wells 4986 and 5186 are screened the length of the well; other wells are screened at the bottom of the alluvium.

FIGURE 2–2

OU 11
HYDROLOGIC DATA

TECHNICAL MEMORANDUM
Revised Field Sampling Plan

3.1 OBJECTIVES AND APPROACH

The purpose of this section is to provide a summary review of the data from historical studies, screening activities, and ongoing monitoring at the WSF. A statistical summary of existing analytical data as compared to background data from the Geochemical Characterization Report (EG&G, 1992c) is presented in Appendix C. Figure 3-1 shows background and OU 11 sample locations. The data sets for OU 11 were QA tested to delete duplicate or rejected data points so that statistical comparisons to background data could be performed.

Historical data include analyses from surface water, groundwater, surficial soils and subsurface materials (Figure 3-1). Data from ecological field sampling (performed in the fall of 1993) is also presented. Surface water data were gathered through the Rocky Flats Surface-Water Monitoring Network. Groundwater data were collected from the RCRA groundwater monitoring program at the plant. Data from surficial soils and subsurface materials were obtained from a 1988 test pit study and recent HPGe screening activities. Data for soils sampling at OU 11 have not been validated. Test pit data will only be used for cursory comparisons to background. No other data exists for comparison purposes. The surface soil sampling program is based upon statistical power considerations and knowledge of historical operations at the WSF. The existing soils and groundwater data have been evaluated to provide justification for re-focusing the investigation in the following areas:

- reducing and focusing the extensive surficial soil sampling program proposed in the original OU 11 Work Plan (EG&G, 1992a);
- identifying additional data requirements from subsurface materials, and;
- completing a groundwater monitoring network at the WSF with wells screened through shallow intervals of the RFA.

Risk from the historical spray application activities at the WSF will be determined by evaluating the additional data proposed and combining it with appropriate historical, ongoing, and screening data.

3.2 ECOLOGICAL FIELD SAMPLING

Objectives and Approach

The assessment of the ecological effects and ecological risks associated with the WSF resulting from RFP activities follows EPA guidance (EPA, 1992). As part of that guidance, data acquisition, verification, and monitoring occur interactively with problem formulation, analysis (characterization of exposure and ecological effects), and risk characterization. The existing ecological data relevant to OU 11 are described below and will be used in problem formulation. Pending the results of the problem formulation, possible future sampling activities are described in section 4.0. All ecological sampling followed Environmental Management Division (EMD) Operating Procedures Manual No. 5-21000-OPS-EE Volume V: Ecology. Specific SOPs are referenced appropriately and listed below.

EE.02	Sampling of Macroinvertebrates
EE.05	Sampling of Large Mammals
EE.06	Sampling of Small Mammals
EE.07	Sampling of Birds
EE.09	Sampling of Terrestrial Arthropods
EE.10	Sampling of Vegetation

Status of Ecological Field Sampling

The status of previous field sampling activities for the OU 11 Ecological Evaluation (EE) are summarized in two tables. Table D-1 summarizes field sampling activities, both completed and proposed, in direct support of the EE for OU 11. Table D-2 summarizes the extensive sampling done under the EG&G Ecological Monitoring Program (EcMP) which may be relevant and applicable to the EE for OU 11. Given the scarcity of ecological impacts associated with Rocky Flats Plant activities, the EcMP evaluated several of its sampling and analysis methods at OU 11. Many of the EcMP endpoints should be very sensitive to the effects of the addition of water and nitrate to the terrestrial ecosystem. Sampling at OU 11 provided the mutually beneficial opportunity to evaluate EcMP methods and add to the state of the art ecological evaluation at this OU.

Terrestrial Ecosystems (Sampling in direct support of the OU 11 EE)

Samples were collected from sprayed areas, non-sprayed areas and reference areas. Within those areas five meter by five meter grids were sampled for vegetation, small mammals and insects (Table D-1). Vegetation sampling included cover transects, belt transects and production quadrants following SOP EE.10. Terrestrial arthropods were collected by sweep netting in all grids of each area following SOP EE.09. Samples are in secure storage awaiting possible identification and enumeration as indicated by the problem formulation. One bird transect, which included portions in both affected and reference areas, was also inventoried following SOP EE.07.

Four grids per area were trapped for small mammals following SOP EE.06. In order to expand the relevance of the small mammal data collected, trapping was done for three nights so that results would be comparable with extensive reference data collected under the EcMP. The small mammals collected included deer mice (Peromyscus maniculatus) and meadow voles (Microtus pennsylanicus). Large mammals were recorded during performance of relative abundance transects following SOP EE.05. The large mammals observed included coyote (Canis latrans), mule deer (Odocoileus hemionus) and desert cottontail (Sylvilagus audubonii).

Vegetation tissue samples were collected by quadrant from all grids within each area following SOP EE.10. Samples of selected species (Poa compressa, Artemesia ludoviciana, Ambrosia psylostachya, and Andropogon gerardii) are in storage in Building T891G at the RFP in a locked room, in custody sealed boxes, in paper bags, holding the dried vegetation at room temperature. Tissue samples await possible analysis as indicated by the problem formulation.

Aquatic Ecosystems (Sampling in direct support of the OU 11 EE)

The only permanent surface water monitoring station with a potential aquatic receptor ecosystem directly down gradient from OU 11 is SW-128. This impoundment principally receives runoff from parking lots and may only be influenced by OU 11 during runoff events. One qualitative benthic macroinvertebrate sample was collected following SOP EE.02 from each, SW-128 and Lindsay Pond. The samples contained a diverse array of 17 and 29 species respectively.

The following preliminary data have been collected or formulated as a result of sample collection in direct support of the OU 11 EE.

- Small Mammal Capture Data
- Vegetation Production Summaries and Calculations
- Vegetation Production Plot Summary Forms
- Vegetation Cover Summaries and Calculations
- Vegetation Cover Transect Summary Forms
- Vegetation Belt Transect Summaries and Calculations
- Vegetation Belt Transect Summary Forms
- Bird Transect Summaries and Calculations
- Relative Abundance Survey Summary
- Species List of Macrobenthic Organisms

Terrestrial Ecosystems (Sampling by the EcMP in support of the OU 11 EE)

The EcMP is a DOE-mandated program to determine long-term ecological endpoints, exposure values and effects at the RFP (DOE Order 5400.1, DOE Order 5440.1E, 43 CFR Part 11, 40 CFR Part 300 Subparts E&G, and 10 CFR Part 384). This program began field operations in 1993, focusing on the testing of methodologies, experimental designs, sample scheduling, and program operations, all of which had been approved by DOE RFO. Soil sampling in OU 11 was conducted in September of 1993. The program had initially been divided into five modules:

- Aquatic ecology;
- Terrestrial vegetation, including cover, richness, density, production and litter biomass values and tissue analysis;
- Ecosystem Functions, including background soil physical/chemical measurements, and microbial carbon and nitrogen pools and potential rates of carbon and nitrogen transformations;
- Soil invertebrate analysis, and
- Small mammal population dynamics.

Many of the ecological endpoints used in the EcMP are still in a state of development for adaptation to monitoring functions, but the endpoints chosen so far have been reviewed by an independent team of western university research experts (Rocky Mountain Universities Consortium, Denver Research Institute, University of Denver) and DOE's ecological consultant (Dr. Beverly Ausmus-Ramses). There is consensus that "best available technology" is being used. In particular, ecosystem function measurements, soil invertebrate analysis, and plant tissue analysis on a cover class basis (as opposed to a species basis) have either not been conducted at the RFP or have been in a very different context than current EcMP needs dictate. Therefore, the testing of methodologies and designs referred to above was critical to the future of the program. Much of the 1993 EcMP sampling took place in the Buffer Zone to define ecological attributes of reference areas. EcMP personnel recognized that the nitrogen treatment in the OU 11 area provided a unique opportunity to examine the feasibility and sensitivity of many program variables. Since many ecological measurements are affected by both carbon and nitrogen flows and pools, if impacts are indeed detectable, we would expect to find them in an area of heavy nitrogen application (OU 11). Therefore, several EcMP measurements were taken in OU 11. Data that are currently available are being analyzed by EcMP personnel to support monitoring activities, but may be used to supplement the OU 11 Environmental Evaluation. These activities are described in more detail in this section. The procedures followed are those of the EcMP. Soil functional, physical, chemical and invertebrate sampling methods are as documented by the EcMP. Vegetation sampling methods used by EcMP are being incorporated into the revised SOP EE.10.

Soil samples could not be collected before radiological screening data were available for review by RFP Radiological Engineering Department. Screening samples were collected from the 0-10 cm depth, the same depth that all soil samples were taken. Five samples for radiological screening analysis were taken; each sample was a composite with soil from five locations. Samples were taken from five north-south oriented strips that encompassed the entire OU 11 area. Samples were delivered that same day to the RFP Building 881 laboratory and analyzed for gross alpha-beta activities. Results indicated total activities (alpha + beta) ranged from 52 to 76 pCi/g.

Soil sampling purposefully followed the same approach of vegetation sampling so that these data will be comparable (Table D-2). Figure 3-2 illustrates that five plots (P1-P5), in each of the four sampling sites, in each of the three treatments (sprayed, nonsprayed, and reference areas) were sampled, for a total of 60 sample units. Twelve additional QA/QC samples were taken for ecosystem function and invertebrate samples. Functional and physical/chemical samples were taken from 0-10 cm depth. Soil invertebrate samples were taken from 0-5 and 5-10 cm depths. All samples were taken with hand tools (shovels, trowels, knives) and transferred to pre-labeled ziplock plastic bags, which also had labels inside the bags. Samples were then placed on blue ice in coolers, sealed, and transferred to a locked room in RFP Building T891 G at the end of the day. Samples were logged onto chain-of custody sheets the same day of sampling or the next morning. Samples were delivered to laboratories within 48 hours, because of the relatively short holding time of the soil functional samples.

Vegetation was collected, dried and weighed by species by plot. Litter was dried and weighed by plot. Subsets of plant tissue were composited after drying (species basis) by plot for nutrient analysis; it was determined that species nutrient data would be less useful information than average above-ground nutrient data on an area basis. Analysis was apportioned as follows: 3 (of 5) plots x 2 (of 4) sites x 3 treatments = 18 sample units. Subsets of litter (corresponding to plant tissue) were analyzed for the same nutrient elements as plant tissue, with the exception that lignin analysis was performed on all litter samples.

Soil sampling was divided into three different areas: 1) functional samples; 2) soil invertebrate samples; and 3) physical/chemical properties. The following lists the analytes for each area:

Soil functional samples:

- extractable soil nitrate (NO_3)
- extractable soil ammonium (NH_4)
- total soil nitrogen
- soil particulate organic matter
- microbial nitrogen concentration (direct extraction)
- microbial carbon concentration (direct extraction)
- potentially mineralizable nitrogen (10 day incubation at field capacity moisture and 25^0 C followed by NO_3 and NH_4 analysis)
- potentially respirable carbon (CO_2 analysis following a 10 day incubation at field

capacity moisture and 25° C)

- nitrogen fixation rate
- denitrification rate

Soil Invertebrate Samples:

- soil arthropod analysis performed on all samples (identification and enumeration)
- soil nematode analysis performed on all samples (identification and enumeration)
- soil mycorrhyzal analysis performed on a subset of samples (presence/absence and inoculation potential)

Soil Physical/chemical properties:

- particle size very coarse sand
- particle size coarse sand
- particle size medium sand
- particle size fine sand
- particle size very fine sand
- particle size total sand
- particle size total silt
- particle size total clay
- soil field water content
- soil water content (0 MPa)
- soil water content (.010 MPa)
- soil water content (.033 MPa)
- soil water content (.5 MPa)
- soil water content (1.5 MPa)
- soil pH, saturated paste, measure suspension
- total soil carbon, CHN analyzer
- soil hydrogen (H), CHN analyzer
- total soil nitrogen (N), CHN analyzer
- soil available phosphorus (P), sodium bicarbonate extract
- soil available potassium (K), sodium bicarbonate extract
- extractable soil iron (Fe), DTPA extract

- extractable soil manganese(Mn), DTPA extract
- extractable soil copper (Cu), DTPA extract
- extractable soil zinc (Zn), DTPA extract
- extractable soil sodium (Na), ammonium acetate extract
- extractable soil potassium (K), ammonium acetate extract
- extractable soil calcium (Ca), ammonium acetate extract
- extractable soil magnesium (Mg), ammonium acetate extract
- extractable soil sulfate (SO_4), HCl extract
- soil cation exchange capacity (CEC), ammonium acetate extract
- soil soluble sodium (Na), water extract
- soil soluble potassium (K), water extract
- soil soluble calcium (Ca), water extract
- soil soluble magnesium (Mg), water extract
- soil digest aluminum (Al), nitric acid digest, EPA method 3050
- soil digest barium (Ba), nitric acid digest, EPA method 3050
- soil digest beryllium (Be), nitric acid digest, EPA method 3050
- soil digest cadmium (Cd), nitric acid digest, EPA method 3050
- soil digest calcium (Ca), nitric acid digest, EPA method 3050
- soil digest chromium (Cr), nitric acid digest, EPA method 3050
- soil digest cobalt (Co), nitric acid digest, EPA method 3050
- soil digest copper (Cu), nitric acid digest, EPA method 3050
- soil digest iron (Fe), nitric acid digest, EPA method 3050
- soil digest lead (Pb), nitric acid digest, EPA method 3050
- soil digest magnesium (Mg), nitric acid digest, EPA method 3050
- soil digest manganese (Mn), nitric acid digest, EPA method 3050
- soil digest molybdenum (Mo), nitric acid digest, EPA method 3050
- soil digest nickel (Ni), nitric acid digest, EPA method 3050
- soil digest phosphorus (P), nitric acid digest, EPA method 3050
- soil digest potassium (K), nitric acid digest, EPA method 3050
- soil digest (Na), nitric acid digest, EPA method 3050
- soil digest sulfur (S), nitric acid digest, EPA method 3050

- soil digest zinc (Zn), nitric acid digest, EPA method 3050
- soil bicarbonate (HCO_3), saturated extract, titration
- soil carbonate (CO_3), saturated extract, titration

Plant and litter tissue were analyzed for the following elements:

- plant ash
- aluminum (Al)
- cadmium (Cd)
- calcium
- chromium (Cr)
- copper (Cu)
- iron (Fe)
- lead (Pb)
- magnesium
- manganese (Mn)
- molybdenum (Mo)
- phosphorus
- potassium
- sodium (Na)
- sulfur
- zinc (Zn)

Aquatic Ecosystems (Sampling by the EcMP in support of the OU 11 EE)

As part of the EcMP initial field sampling effort, SW-128 and Lindsay Pond were sampled for zoobenthos, emergent insects, phytoplankton, zooplankton and water chemistry. Table D-2 summarizes the samples that were taken. These data may be used in Problem Formulation and for a weight of evidence approach to the detection of any "impacts" on SW-128.

Summary of Preliminary Ecological Findings

Small mammal capture data collected in the Fall of 1993 were inconclusive due to low numbers of captures in both the reference site and the sprayed and non-sprayed sites at OU 11. It is likely that the low numbers of captures are due to the absence of burrowing sites in the upland soils of the WSF. A re-sampling of small mammals in OU 11 is scheduled for the spring of 1994 to strengthen the data base and substantiate preliminary findings.

Vegetative cover data showed lower basal cover in sprayed versus non-sprayed and reference areas. Belt transect data suggested this might be due to the change in species composition resulting from supplemental nitrogen and water additions. Subsequently, the production data showed higher plant biomass in sprayed versus non-sprayed and reference areas. The data also suggested a much higher litter biomass on sprayed versus non-sprayed and reference areas. From these preliminary data, our tentative conclusion is that the water and nitrogen supplement has resulted in a greater biomass of large bunch grasses such as big (Andropogen gerardii) and little bluestem (Schizachyrium scoparium). These results may be analogous to those from watering and fertilizing a lawn heavily and then withdrawing the external treatments, resulting in less cover but elevated litter and biomass.

No differences were found between transect locations associated with sprayed versus non sprayed or reference locations in the relative abundance survey. Breeding bird results suggest higher bird densities on the WSF than on the reference areas. The WSF had the highest population of grasshopper sparrows (Ammondramus savannarum) of any location sampled on the plant site. These birds prefer higher stratum grass habitats than other species such as the savannah sparrow (Passerculus sandwichensis). Aquatic habitat species composition at surface water location SW-128 showed no obvious loss of sensitive species. Overall, this preliminary evaluation of the available data showed no evidence of biotic effects between the treatment and reference areas associated with historical spraying activities at the WSF.

3.3 SOILS SAMPLING

Two historic soil sampling programs were conducted at the WSF to determine if immediate removal actions were necessary. The sampling programs took place in 1986 and 1988 to provide information for the Part B RCRA Permit Application (Rockwell International, 1986). The data from sampling indicated that immediate removal actions were not necessary. Although the data from these two studies was not validated, the results corroborate each other and the data have been used only as a cursory view of potential OU 11 contamination at the WSF, not for characterization purposes. No previous investigation of soils below five feet has been conducted.

Surface Soils

Surface Soil Sampling

In 1988, 12 test pits were excavated at points where spray concentrations were expected to be a maximum. Thirty-six samples were collected to a depth of five feet and analyzed for constituents known to have been in the applied liquid. The analysis included select metals, radionuclides, nitrate/nitrite, and volatile organic compounds (VOCs). These data provided a preliminary view of the contamination at the WSF. For comparison purposes, analytical data samples composited from the upper two feet of soil (Layer 1) were compared to Rock Creek analytical data (the upper five centimeters of soil) and are presented in Appendix C. While these comparisons are not ideal, appropriate data for comparison is not available, and soils data in Appendix C is only used for informational purposes. A major goal of the investigation proposed in this TM is to provide a data set that will be validated and comparable to background data.

Gamma Surveys

Two gamma surveys have been conducted at the WSF. In July of 1989, an aerial gamma survey of the RFP and surrounding areas was performed by EG&G Energy Measurements. The aerial survey, which measured gamma radiation, provided an estimate of the distribution of isotope concentrations around the plant. Results were reported on isoradiation contour maps and included measurements of americium-241 and cesium-137 (EG&G EM, 1989).

A ground-based High Purity Germanium (HPGe) gamma survey was performed at OU 11 in September and October of 1993 in order to provide baseline information for worker safety during future field investigations, and to aid in the characterization of surface soils. Resulting data is presented in Appendix G of this TM. The instrument operated at a height of 6.5 meters and measured emissions within a radius of approximately 150 feet. Ninety-five percent of the detectable gamma-ray emissions originated within the counting area or field of view (information concerning the capabilities and limitation of the HPGe system can be obtained in the "Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant" (EG&G, 1993a)). Contour maps of the aerial gamma survey and the OU 11 HPGe survey are presented in Figures 3-3 and 3-4, respectively.

Summary

The soil sampling study conducted in 1988 is summarized in Appendix C (Table C-4). Values from the 1988 study are compared with Rock Creek data, where possible. Activities for individual radionuclides are slightly higher at the WSF than at Rock Creek. Lead, mercury and nitrate/nitrite were also analyzed in the 1988 soil sampling study. Nitrate and lead were present above background concentrations in some samples. Some of the results were noted in the original lab report as requiring re-analysis. Results of VOC analyses in surface soils at OU 11 showed the presence of acetone and trichloroethane only. Both VOCs are common laboratory solvents. It is unlikely that VOCs would have been adsorbed onto soil particles because the act of spraying would probably have caused the organic compounds to volatilize and dissipate if present in the spray liquid.

Aerial gamma exposure rates measured at OU 11 are lower than those measured on plantsite and other surrounding areas (11-13 micro-rems per hour (μR/h) for OU 11 and 15-17 μR/h for surrounding areas). Figure 3-3 shows gross count exposure rates superimposed on a photograph of the Rocky Flats area (EG&G EM, 1989). Figure 3-4 presents data from the HPGe survey. Gamma exposure rates ranged from 5 to 8 μR/h. Differences in levels of gamma radiation are due to the differences in the height of the instrument during surveying, extrapolation techniques, and error considerations. Both studies have shown that surficial gamma radiation at OU 11 is lower than the average for the RFP and surrounding background areas (between 5 and 13 μR/h).

Subsurface Soils

The spray application at the WSF resulted in low concentrations of contaminants being spread over large areas. The evapotranspiration rate is high in the RFP area and constituent concentrations are anticipated to be higher in surface soils than in subsurface soils or groundwater. Historical investigations focused on surface and shallow subsurface soil sampling. For data comparability purposes, data from soil layers 2 and 3 of the 1988 test pit study were combined, because they are from three to five feet below the surface and are Rocky Flats Alluvium (RFA) materials. Data from these layers were compared with background data from the RFA from the Final Background Geochemical Characterization Report (EG&G, 1992c) and are summarized in Table C-5.

Activities from radionuclides in subsurface soils at OU 11 were all higher than established background activities (EG&G, 1992c). This difference in activities occurs because the sample means for background radioactivity in the RFA were calculated for deeper intervals than the samples taken at OU 11. Because radionuclides tend to "cling" to soil particles, it is expected that they would have higher activities in upper layers of soils (EG&G, 1993c). This behavior is also reflected when comparing the OU 11 sample means for Pu-239/240 in subsurface soils (two feet to five feet in depth), which are less than sample means for Pu-239/240 in OU 11 surface soils activities (one foot to two feet) in depth) by 0.12 pCi (uranium values went up slightly with depth, which is to be expected with naturally occurring radionuclides). Further investigation for radionuclides in subsurface soils is proposed in Section 4 of this TM.

Sample means for nitrate and lead were also higher than those for background. Further investigation of nitrate/nitrite and metals is proposed in Section 4 for the same reasons mentioned for surface soils.

3.4 SURFACE WATER

Surface water data was collected through stations set for the Rocky Flats Surface-Water Monitoring Network in 1989 and 1990. Because standing water does not exist at the WSF, only discharges from storm events could be monitored. Background data for storm events is unavailable, and although data comparability is questionable for storm water and surface water. Orthophosphate is present in surface water, but it is the most stable of the oxidated phosphorus forms. Aluminum, lead and zinc are analytes that appear consistently in surface water, which is expected for leachable metals applied to surface areas. No surface water sampling is anticipated as part of this investigation.

3.5 GROUNDWATER

RCRA regulations require a groundwater monitoring program be implemented which is capable of determining the impact of a RCRA regulated unit on the upper most hydrostratigraphic unit. To meet this requirement, 17 groundwater monitoring wells have been installed in and near the

WSF. Prior to the 1986 RCRA monitoring program, few wells were installed and these have since been abandoned due to incomplete well construction information.

Routine groundwater monitoring at the WSF began in 1986. This monitoring is being conducted to provide data for assessment of nature, extent, and migration characteristics of contamination in the unconfined "aquifer", commonly referred to as the upper hydrostratigraphic unit (Rockwell International, 1987). Groundwater flow in the upper hydrostratigraphic unit moves in an east-northeasterly direction with a typical hydraulic conductivity of 4.4×10^{-1} feet per day (EG&G, 1993b). Fourteen alluvial wells and three bedrock wells are routinely sampled at the WSF. Three of these wells are screened through the entire thickness of the RFA and the rest are screened in the 20 foot interval above the bedrock. This arrangement adds uncertainty to the understanding of chemical distribution in the subsurface because the wells screened through the entire interval have higher contamination levels than do those completed only in the lower saturated zone, indicating the possibility of contamination in shallow groundwater beneath the WSF (See Section 4.5 for more detail).

Groundwater quality in the upper hydrostratigraphic unit in downgradient wells was compared with that of the upgradient wells and with background groundwater quality (Section 4.5 and Appendix C). A summary of these data and data presented in the RCRA Groundwater Monitoring Report (EG&G, 1994) is presented below.

- Within the WSF, detection of volatile organic compounds in groundwater has been inconsistent and extremely limited. During 1991, the only VOC detected was toluene from well number 4986 only in the fourth quarter. For 1992, xylene was detected in well number B110889 during the fourth quarter. The analyte most frequently detected was methylene chloride, a common laboratory contaminant. Detections of methylene chloride occurred only in the second quarter of 1993 from wells 46292 and 5086. Acetone was detected in the third quarter of 1993 in groundwater from well B410789. These detections were not repeated in subsequent quarters of 1993 and are not considered to be indicative of contamination.

- Uranium-238 was detected in wells 4986 (third quarter only) and B410789 (first and second quarters) in 1991. Uranium-233/234 was detected in well B410789 for the first and second quarters of 1991. Plutonium and americium were found in upgradient well 5186 in the second quarter. For 1992, well number 5086 showed levels of americium and plutonium in the first quarter only. Americium was also detected in well 4986 in the third quarter. Well B410789 had americium, uranium-238 and uranium-233/234 in the first quarter. In 1993, the only radionuclide to exceed background values was radium-228 in the first quarter at well number 5086. Other radionuclides detected in 1993 were strontium, radium-226, uranium-233/234, 235, and 238, tritium, and plutonium.

- Concentrations of uranium-233, 234 were detected in five downgradient wells but were within the upper tolerance limits of background values.

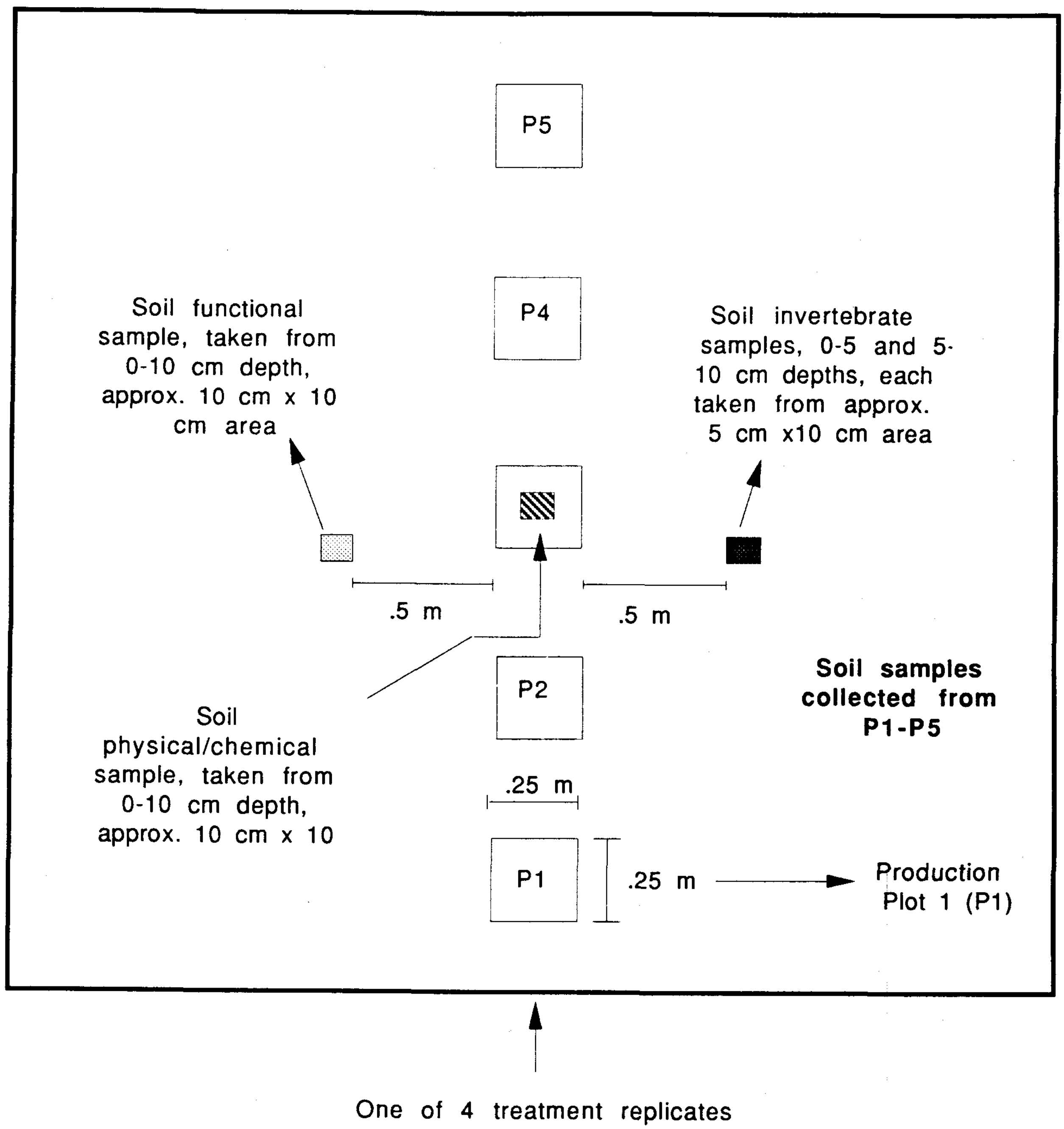
- Calcium, chloride, fluoride, silicon, and sodium were measured at greater concentrations in the downgradient monitoring wells than in upgradient wells; sulfate, nitrate/nitrite, magnesium and total suspended solids all were measured at higher concentrations in upgradient monitoring well number 5186 than in downgradient wells.

A discussion concerning the existence of constituents in groundwater beneath the WSF that are above background levels may be found in Section 4.6, Analytical Requirements. Section 4.6 also describes the proposed plan for analysis.

Seismic Information

A seismic study was performed in February of 1992 as a part of the Geologic Characterization Data Acquisition Plan (EG&G, 1992d). Data from the seismic study will not be used for OU 11 characterization purposes until the data is verified through the drilling proposed in this TM. The seismic information is considered unusable for this very shallow WSF study due to calibration issues. If drilling information proves the seismic instrumentation to have been calibrated correctly, data from the seismic study will be used in the RFI/RI Report. The location of the seismic line at the WSF can be seen in Figure 4-2.

Figure 3-2 Ecological Soil Sampling Scheme



4.1 OBJECTIVES AND APPROACH

The objective of this FSP is to provide the scope for collecting additional data necessary to sufficiently characterize the WSF in order to evaluate the potential risk from the site. The RFI/RI Report and risk assessment for OU 11 require adequate data coverage of the area. Data gaps were identified by assessing historical data, performing preliminary investigations (i.e. the ground-based radioisotope survey), and determining parameters needed to fully evaluate contamination pathways. Each section described below provides justification for locations, amounts, and types of sampling. In addition, process knowledge of Solar Pond water constituents, known locations of areas that received maximum spray, and geologic modeling information are taken into account. Table 4-1 presents a comparison of sampling activities from the original OU 11 Work Plan (EG&G, 1992a) and revisions to that Work Plan as presented in this TM. Table 4-1 also presents justifications for revisions to the original OU 11 Work Plan. Table 4-2 summarizes the activities detailed in this TM.

4.2 ECOLOGICAL FIELD SAMPLING PLAN

Proposed sampling activities which have not been completed to date are highlighted in Table D-1, and an explanation as to the status of these activities is provided in the footnotes of this table. Pellet counts are scheduled for sampling in the spring of 1994. All proposed tissue sampling or proposed tissue sample analyses await the results of the problem formulation and regulatory agency guidance as to the efficacy of this effort for OU 11. Quantitative sampling of aquatic biota may occur during the spring of 1994 pending problem formulation and regulatory agency guidance.

The Ecological Evaluation/Ecological Risk Assessment for OU 11 will be prepared following a three-phased approach based upon the EPA's *Framework For Ecological Risk Assessment* (EPA, 1992), and will consist of the following:

A. Problem Formulation,

B. Analysis - Characterization Of Exposure and Characterization of Ecological Effects, and

C. Risk Characterization if any adverse effects are observed

At the conclusion of each phase, a formal presentation will be given to the regulatory agencies along with a report for review and concurrence.

4.3 SOIL SAMPLING PLAN

Surficial Soil Sampling Plan

Fewer surface soil samples are required for the investigation of potential contamination of the WSF than are proposed in the conditionally approved OU 11 Work Plan (EG&G, 1992a). Analysis of available data, statistical power considerations for comparing site and background means, and the inapplicability of statistical hot spot detection (due to the method of spray application) all indicate the need for fewer samples. The original FSP called for a uniform sampling grid over the entire spray field with 300 foot spacings which resulted in the need for collecting and analyzing 75 surface soil samples. Adequate comparisons to background and additional comparisons within the spray fields can be made based on fewer samples. A sampling scheme that will allow for comparisons of spray and channel areas within the spray fields, as well as potential hot spot locations (based on process knowledge) is presented.

In an attempt to meet power criteria in the comparison of site and background, along with a desire to detect hot spots, the need for 75 surficial soil samples was presented in the original OU 11 Work Plan (EG&G, 1992a). With a grid spacing of 300 feet, to detect an existing hot spot with probability of .90, the appropriate statistical standard, the hot spot would need to have a diameter of approximately 168 feet. To attain the same detection probability for a 50 foot hot spot, the grid for the WSF would require 1000 surface soil samples (see Appendix E for a thorough explanation) .

In areas of potentially greater risk, the sampling design should determine if analytes are elevated with respect to other areas within the OU as well as with respect to background. This design should be applied to the WSF, as the areas of higher risk are the areas of spray application, which are well documented, and runoff channels, which can be located on aerial photos. The revised surface soil sampling plan allows for the comparison of runoff channels, spray areas, areas that were neither sprayed or runoff channels, and locations for potential hot spots.

This surficial soil sampling plan abandons the systematic grid approach for detecting hot spots in favor of specifically locating samples in areas of special interest. For the WSF, such areas are the discharge channels, spray contact areas, and pipeline junctures. It is recommended that 11 samples be taken from channels within spray areas, 7 samples be taken from channels outside of spray areas, 10 samples be taken from outside channels in spray areas, 6 samples be taken from outside of both runoff channels and spray areas, and 4 samples be taken on known pipeline junctures (Figure 4-1). This gives a total of 38 samples and provides data on which to base internal OU comparisons. The locating of samples within the various areas could be done randomly, but this approach is not necessary for reasonable inferences to be made.

Surface soil sampling will be performed in accordance with the "Rocky Flats Method" as outlined in SOP GT.08. This method requires the compositing of five samples for each sample location, generating data from a larger area. The "Rocky Flats Method" was the method used for background sampling, and therefore should be used at the WSF for comparison purposes. Adequate characterization of surface and shallow subsurface materials can be obtained from the sampling activities proposed in this section.

<u>Subsurface Soil (Sediment) Sampling Plan</u>

Subsurface soils will be sampled from the monitoring well locations described in Section 4.5 and Figure 4-2. Two foot composites will be collected to a depth of twelve feet. From twelve feet to the saturated zone, six foot composites will be taken. If a clay layer is encountered, that section will be sampled discretely. If perched water is encountered, equipment for monitoring groundwater will be installed at the depth of perched water. Approximately 120 borehole samples will be taken using this sampling strategy. Section 4.5 details sampling methodology.

For a more complete analysis, geophysical logs will be taken on existing RCRA groundwater monitoring wells at the WSF and the wells installed in accordance with this sampling plan. Geophysical data will be collected in accordance with RFP SOP GT.15.

4.4 SURFACE WATER

This revised FSP does not include sampling for surface water. Since no permanent surface water exists at OU 11, only storm events can be monitored at OU 11. The only analytes that appear above background are essential nutrients and major rock constituents (even the comparison to background is questionable, as background figures are from pond sampling). Finally, any surface contamination that would cause surface water runoff contamination will be examined through the surface soil sampling program described previously.

4.5 GROUNDWATER MONITORING PLAN

Current Monitoring Network

An extensive network of groundwater monitoring wells exists in or near OU 11. These wells are screened in the uppermost hydrostratigraphic unit (RFA) for the purpose of monitoring the saturated zone. This network includes two upgradient wells, five wells within the WSF boundary, six wells on the downgradient IHSS boundary, and an additional eight wells downgradient or to the sides of the IHSS. This monitoring design was developed to monitor the non-point source dissemination of potential contaminants into the environment.

Perched Groundwater Conditions

Data supporting the existence of perched groundwater include historical water level data, water chemistry data, and information gathered during recent drilling operations. If WSF spray activities have contributed significant levels of contamination to the groundwater, perched areas of groundwater have the potential of having the highest levels of contamination.

The screened intervals of the wells in the current monitoring system are either too deep to monitor perched conditions, or are screened through the entire thickness of the RFA. The three wells with extensive screened intervals are 4986, 5186, and B410789. Well number 5186 is upgradient of Spray Area 1, but may been contaminated with nitrates from OU 11 due the mounding effect of perched water from spray activities. The nitrate/nitrite concentrations in the three wells do not constitute a concern in terms of nitrate/nitrite groundwater standards (10 mg/L), (EPA 1993b); however, they may represent a dilution of shallow (perched) groundwater contamination with deeper groundwater from the saturated zone.

Four wells (1081, 582, 682, and 782) were drilled in the WSF area to depths of approximately 25 feet for the purpose of monitoring shallow groundwater conditions. Water level measurements taken at these locations indicate that shallow groundwater exists at depths of between 20 and 25 feet. Because well construction details for these wells were not available, all four wells were recently abandoned through WARP (Well Abandonment and Replacement Program).

Additional evidence of perched groundwater conditions was obtained when replacement wells 46192 and 46292 were drilled to bedrock. These wells were drilled with hammer technology using air as a drilling fluid. Sample returns indicated that water was encountered at a depth of approximately 25 feet.

Locations of Proposed Boreholes and Monitoring Wells

For the purpose of obtaining additional subsurface information, ten wells will be installed in the WSF (Figure 4-2). The main criterion for the selection of well locations was that the wells be located within the irrigation sub-basins or areas which received direct spray application. Additional criteria included proximity to wells where contamination has been documented, proximity to wells where shallow groundwater was encountered upon drilling of wells previously abandoned, position relative to surface runoff pattern, and position relative to the seismic data.

Seismic data were evaluated as a tool for locating boreholes and wells; however it was concluded that the WSF seismic line had not been adequately calibrated to the subsurface geology. In addition, seismic processing was intended to enhance deeper portions of the geologic section rather than the uppermost 30 feet, where perched mounds are anticipated. For the purpose of validating the seismic data for future use, two boreholes will be located on the seismic line. Listed below are the well locations for the six proposed wells.

WSF 1	•	Provides northwest area coverage.
	•	Located beneath historical pipeline location.
WSF-2	•	Near well 5186, where elevated nitrate concentrations have been recorded.
	•	On seismic line.
WSF-3	•	Fills in area of insufficient data.
	•	On historical pipeline location.
WSF-4	•	Provides coverage of northernmost area of Spray Area 2.
WSF-5	•	Near well #4986, where the highest level of nitrate/nitrite was recorded.
	•	On the seismic line.
WSF-6	•	Centrally located in Spray Area 3, where there is a lack of data.
WSF-7	•	Provides coverage of the southwest corner of OU 11.
	•	On historical pipe location.
WSF-8	•	Provides coverage in the south central portion of the WSF.
WSF-9	•	Fills in data gap in the direction of groundwater flow from Spray Area 1.
WSF-10	•	Provides coverage in the southeast area of the WSF.

Monitoring Well Installation Program

As described above, six boreholes will be drilled for the purpose of characterizing subsurface lithologies and sampling perched water conditions if present (detailed later in this section). Results from drilling, borehole sampling, and groundwater monitoring will be used to assess the need for further characterization of OU 11.

Activities related to the Monitoring Well installation Program will be carried out in accordance with all applicable Environmental Management Division SOPs. The following EMD SOPs are applicable in this program.

FO.01	Monitoring and Dust Control
FO.02	Transmittal of Field QA Records
FO.03	General Equipment Decontamination
FO.04	Heavy Equipment Decontamination
FO.05	Handling of Purge and Development Water
FO.06	Handling of Personal Protective Equipment

FO.07	Handling of Decontamination Water and Wash Water
FO.08	Handling of Drilling Fluids and Cuttings
FO.09	Handling of Residual Samples
FO.10	Receiving, Labeling, and Handling Environmental Materials Containers
FO.11	Field Communications
FO.12	Decontamination of Facility Operations
FO.13	Containerization, Preserving, Handling, and Shipping of Soil and Water Samples
FO.14	Field Data Management
FO.16	Field Radiological Measurements
FO.18	Environmental Sample Radioactivity Content Screening
FO.23	Management of Soil and Sediment Investigative Derived Materials (IDM)
FO.29	Disposition of Soil and Sediment Investigation-Derived Materials
GW.01	Water Level Measurements in Wells and Piezometers
GW.02	Well Development
GW.05	Field Measurement of Groundwater
GW.06	Groundwater Sampling
GT.01	Logging Alluvial and Bedrock Material
GT.02	Drilling and Sampling Using Hollow-Stem Auger Techniques
GT.04	Rotary Drilling and Rock Coring
GT.05	Plugging and Abandonment of Boreholes
GT.06	Monitoring Well and Piezometer Installation
GT.10	Bore hole Clearing
GT.17	Land Surveying
GT.24	Approval Process for Construction Activities on or near IHSSs

Justification of Preferred Drilling Technology

Sonic Drilling and split spoon sampling are the preferred drilling and sampling technology to be used. The advantages of utilizing sonic drilling are summarized below. A Document Modification Request (DMR) pertaining to sonic drilling will be written for EMD SOP GT.02, Drilling and Sampling Using Hollow-Stem Auger Techniques.

Achieving good sample recovery for lithologic and chemical characterization is the main objective of using sonic drilling. Most of the wells previously drilled on OU 11 were drilled with hammer technology. Lithologic logs of these wells lack accuracy and detail. Hollow-stem auguring, the standard method of drilling boreholes at RFP, can provide undisturbed samples for analyses, and this technique may be adequate; however there is a risk of obtaining poor sample recovery in the unconsolidated sands and gravels of the RFA. Because the perched zones of interest are relatively thin, good sample recovery is critical to characterization efforts.

Sonic drilling technology has a distinct advantage for use at RFP over conventional auger and percussion drilling because it allows continuous sample retrieval through cobbles and boulders. By utilizing a relatively high-frequency oscillating drill head combined with downward pressure and low rotation, the drill string is advanced through unconsolidated and consolidated materials. Additional advantages of sonic drilling are: its rapid rate of penetration; the generation of small drilling waste volume at the drill site; and the speed and ease of development of monitoring wells (critical in perched zones where little water may be available for well development).

Sonic drilling has a limited track record in the environmental industry. Approximately two years ago, sonic drilling was used for a site assessment of the RFP Wind Site. The program was experimental and involved modifications to standard sonic drilling equipment. Problems with sample recovery were encountered, including plugging of the drill bit and recoveries of greater than 100 percent (probably due to expansion of sample and extension of the sample in the core barrel which has a smaller diameter than that of the drilling bit). Sonic drilling technology has improved since it was employed at the Wind Site, and reports of is success at other sites, such as Hanford, have been received. However, due to the limited use of sonic drilling in the environmental industry, the first well at the WSF will be a test case. If drilling objectives are successfully met, the remaining five wells will be drilled in a similar manner. In the event that sonic drilling is not successful in a test case scenario, hollow stem augering will be used as an alternative.

Drilling Procedures and Borehole Sampling

As stated above, Sonic Drilling will be employed, and core samples will be collected in a split spoon sampler. Visual logging of the alluvial materials will be performed according to SOP GT.01, Logging of Alluvial and Bedrock Material. All sampling equipment will be protected from the ground surface with clear plastic sheeting. Sampling procedures are defined in SOP GT.02, Drilling and Sampling Using Hollow-Stem Auger Techniques. Appendix G of this TM describes procedures to be used for sonic drilling in addition to GT. 02. In addition, samples for water content measurements will be collected every two feet. Water content measurements will be determined in the field and also in a geotechnical laboratory. Water content data for each borehole will be collected in the field using a "Speedy Soil Moisture Tester", manufactured by Soiltest Incorporated or other field water content instrument, and will be used to design each monitoring well. Samples released to the geotechnical laboratory will be stored after analysis for future use, if future vadose zone characterization is deemed necessary. These samples might be used to construct moisture characteristic curves. Drilling and sampling activities will be conducted in accordance with the OU 11 Site-Specific Health and Safety Plan.

All drilling equipment, including the rig, water tanks, drill rods, samplers, etc., will be decontaminated before arrival at the work site. The drill rig will be decontaminated between each borehole, and sampling equipment will be decontaminated between samples. Equipment will be inspected for evidence of fuel oil or hydraulic system leaks. SOP FO.03, General Equipment Decontamination and SOP FO.04, Heavy Equipment Decontamination will be adhered to. If lubricants are required for down-hole equipment, only pure vegetable oil will be used.

Prior to drilling, approval for construction activities will have been obtained in accordance with SOP GT.24, and drill sites will have been cleared in accordance with GT.10. Well locations will have been surveyed, numbered, and identified with stakes. During site preparation, an exclusion zone will be established according to the Site-Specific Health and Safety Plan, and the drill rig will be set up. The objective of well installation is to monitor groundwater quality in potentially contaminated perched mounds. The monitoring network in the saturated zone is complete, and no new wells will be constructed to monitor this portion of the uppermost hydrostratigraphic unit. The total depth of each well will be determined by the project manager. Holes will be drilled to penetrate a perched saturated zone (if encountered) and underlying aquitard. If a perched groundwater table is encountered, a monitoring well will be installed in accordance with this TM. If a perched groundwater table is not encountered, the boring will be advanced to the saturated zone. At that time the project manager will determine if the borehole should be abandoned in accordance with GT.05 or drilled to the alluvial/bedrock contact for the purpose of supporting the OU 11 data acquisition plan. Since OU 11 subsurface lithologic data is incomplete, boreholes may be advanced to penetrate the entire RFA. After a borehole has been advanced to the saturated, it will be monitored quarterly for one year and then, dependent upon analysis, will be abandoned in accordance with GT.05. Boreholes will be sampled in accordance with SOP GT.02, Drilling and Sampling Using Hollow-Stem Auger Techniques or in accordance with a DMR for a split core sampler used with a sonic drilling rig, depending upon the most appropriate technology as determined by subsurface conditions. Boreholes will be lithologically logged in accordance with SOP GT.01, Logging Alluvial and Bedrock Material and geophysically logged in accordance with SOP GT.15, Geophysical Borehole Logging. During drilling operations, the cuttings will be containerized according to SOP FO.08, Handling Drilling Fluid and Cuttings and FO.23, Management of Soil and Sediment Investigative Derived Materials (IDM).

Gamma-Ray/Neutron geophysical logging will be performed for each new well. In order to provide better lithologic characterization, wells currently in the vicinity of and within the WSF will also be geophysically logged. The logging of these wells should provide possible migration information through lithologic correlation.

For the purpose of defining extent of potential vadose zone contamination, soil samples will be collected from ground surface to the saturated zone. At each boring location, two-foot composite samples for chemical analyses will be collected from ground surface to a depth of 12 feet and six foot composites will be taken from 12 feet to the saturated zone, with discrete samples taken at locations where perched water is located. If perched water is not encountered at or before 30 feet, then the well will be completed in the saturated zone. Figure 4-3 summarizes the drilling decisions and subsequent activities flow.

Samples will be analyzed for the analytical parameters as defined in Section 4.6. The recovered material will be classified, logged, peeled disaggregated, mixed into a composite, and placed in appropriate containers for laboratory analysis according to SOP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples. Procedures for sample peeling, handling and compositing will be followed according to SOP GT.02, Drilling and Sampling Using Hollow Stem Auger Techniques.

Subsequent to sample collection the exterior of the sample containers will be decontaminated according to FO.03, General Equipment Decontamination, and placed in coolers lined with a plastic bag designated for sample transportation. Blue ice or equivalent will be placed in each cooler. Official custody of samples will be maintained and documented from the time of collection until the time that valid analytical results have been obtained or the laboratory has been released to dispose of the sample. Chain-of-Custody procedures will be in accordance with SOP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples.

Monitoring Well Installation Procedures

As specified in the IAG, groundwater monitoring wells will be installed according to SOP GT.06, Monitoring Well Installation, which is outlined below.

The screen intervals of all wells will be sufficient to monitor perched groundwater conditions. The well design specifics for each well will be determined after the bore hole has been drilled and the water content measurements and lithologic data have been analyzed. It is anticipated that the well will be two inches in diameter upon completion. However, since new drilling technologies are anticipated, the casing size will be evaluated so that the ratio of filter pack to well diameter is appropriate. The objective is to maintain an approximate two inch filter pack around the well bore annulus. Well casings will consist of new, threaded, flush-joint, schedule 40 poly-vinyl chloride (PVC). The well casing will extend from the top of the well screen to approximately two feet above ground surface. The tops of all well casings well be fitted with slip-on or threaded PVC caps. All joints within the casing string will be threaded. O-rings will be used, or polytetrafluoroethylene (PTFE) tape will be wrapped around the joint threads to improve the seal. All well casings will be steam cleaned and stored in plastic sleeves prior to use.

Well screens will be placed in a manner to optimize the groundwater flow from the perched zone into the well bore. The bottom of the screened interval will coincide with the top of the underlying aquitard. Well screens will consist of new threaded PVC pipe with the 0.010-inch factory-machined slots or wrapped screen. The wall thickness will be the same as the well casing, so that the screen Inner Diameter (ID) is equal to or greater than that of the well casing. A sediment sump will be constructed beneath the screen, such that the sump extends at least six inches below the perched aquifer but does not extend below the bottom of the aquitard. If the aquitard is greater than two feet thick, a two-foot deep sediment sump will be constructed.

Filter pack material will be chemically inert, rounded silica sand of approximately 16-40 gradation. The particulars of filter pack placement will depend on the thickness of the perched water zone and underlying aquitard. The filter pack will extend approximately two feet above the well screen and at least six inches below the well screen base. If the aquitard is of sufficient thickness for a two-foot sediment sump, the filter pack will extend two feet below the bottom of the well screen.

Bentonite pellet seals will be installed above and below the filter pack for the purpose of isolating the perched water zone. The bottom seal will consist of a minimum of three feet of bentonite pellet backfill material, and the upper seal will consist of a minimum three-foot bentonite pellet layer, installed between the formation and well casing. The thickness of the bentonite seals should be measured immediately after placement, without allowance for swelling. Bentonite should be placed in a manner so that it does not get hung up in the screened interval during emplacement, as bentonite can alter the pH of the formation water.

<u>Monitoring Well Development and Sampling Procedures</u>

Monitoring wells will be developed for groundwater sampling as specified in SOP GW.02, Well Development. Monitoring well development is the process by which the well drilling fluids and mobile particulates are removed from within and adjacent to newly installed wells. The objective of well development activities is to provide groundwater inflow that is as physically and chemically representative as possible of the hydrostratigraphic unit or aquifer.

Well development will be conducted as soon as practical after installation, but no sooner than 48 hours after grouting and pad installation is completed. Monitoring wells will be developed utilizing low energy methods. An inertial pump or bottom discharge/filling bailer will be used in development activities.

All newly installed wells will be checked for the presence of immiscible layers prior to well development. Once determined free of an immiscible layer, a water level measurement will be taken according to SOP GW.01, Water Level Measurements in Wells and Piezometer, and well development activities will proceed. The water level measurement along with the total depth measurement and the diameter will be used to determine the volume of water in the well casing.

Formation water and fines will be evacuated by slowly lowering and raising the inertial pump or bailer intake throughout the water column. Development equipment, including bailers and pumps, will be protected from the ground surface with clear plastic sheeting. The equipment will be decontaminated before well development begins and between well site activities according to SOP FO.03, General Equipment Decontamination.

Estimated recharge rates will be measured following the procedures outlined in SOP GW.01, Water Level Measurements in Well and Piezometers.

Groundwater sample collection will be performed in accordance with SOP GW.06, Groundwater Sampling. The groundwater will be sampled and analyzed for analytes included in the Analytical Requirements section (Section 4.6) of this TM, provided sufficient groundwater is collected.

The following field measurements will be obtained at the time of sample collection:

- pH
- specific conductance
- temperature
- dissolved oxygen
- barometric pressure

If there is not enough groundwater to sample for all analytes, the analytical priority stated in the Analytical Requirements section (Section 4.6) will be followed. Samples will be handled according to SOP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples, and FO-03, General Equipment Decontamination.

4.6 ANALYTICAL REQUIREMENTS

Surficial Soils

The analytical suites for surficial soil samples were developed based on Solar Pond water analyses (Appendix A), historical sampling results, and the geochemical behavior of contaminants. Target Analyte List (TAL) Metals can be found in Appendix F of this TM. Surficial soil samples collected for this sampling program will be analyzed for the following:

- Uranium 233/234, 235, 236, and 238;
- Plutonium and Americium;
- Tritium;
- TAL Metals, and;
- Nitrates.

Surficial soil samples will not be analyzed for volatile and semi-volatile organic compounds due to the volatile nature of the compounds and the elapsed time since the last spray application. This list of analytical parameters is similar to that in the original OU 11 Work Plan (EG&G, 1992a). The original Work Plan also recommends additional suites for analysis for test pit samples. Those analytes will be examined through the drilling program.

Subsurface Soils

As mentioned earlier, the analytical requirements for subsurface soils (RFA materials) is equivalent to the test pit sampling parameters in the original OU 11 Work Plan. Target Compound List (TCL) organics can be found in Appendix F. Subsurface soils will be analyzed for the following chemical and radionuclide parameters or parameter groups:

- Nitrates;
- TAL Metals;
- Uranium 233/234, 235, 236, and 238;
- Plutonium and Americium;
- Tritium;
- TCL volatile organics, and;
- TCL semi-volatile organics

If sonic drilling actvities produce too much heat to quantitatively sample for TCL VOCs and semi-VOCs, then they will be sampled on a quantitative basis.

Groundwater

If perched groundwater is encountered, the following analytical parameters will be analyzed in the priority as listed if groundwater volumes are not enough to allow for sampling of all parameters:

- Nitrates;
- Uranium 233/234, 235, 236, and 238;
- Plutonium and Americium;
- Tritium;
- TAL Metals;
- TCL volatile organics, and;
- TCL semi-volatile organics.

Logic for the priority listing is as follows:

Priority	Analyte	Logic
1	Nitrates	Process knowledge demonstrates that nitrates were a major constituent of spray water, and nitrates exist at varying levels in different wells at the WSF
2	Radionuclides	Historical analyses of Solar Pond water showed low concentrations of radionuclides.
3	TAL Metals	TAL metals are included for a complete analysis.
4	Volatile organics Semi-volatile organics	Volatile and semi-volatile organic compounds are the least likely expected contaminant, as they did not appear in Solar Pond water analyses and would likely have volatilized upon spraying.

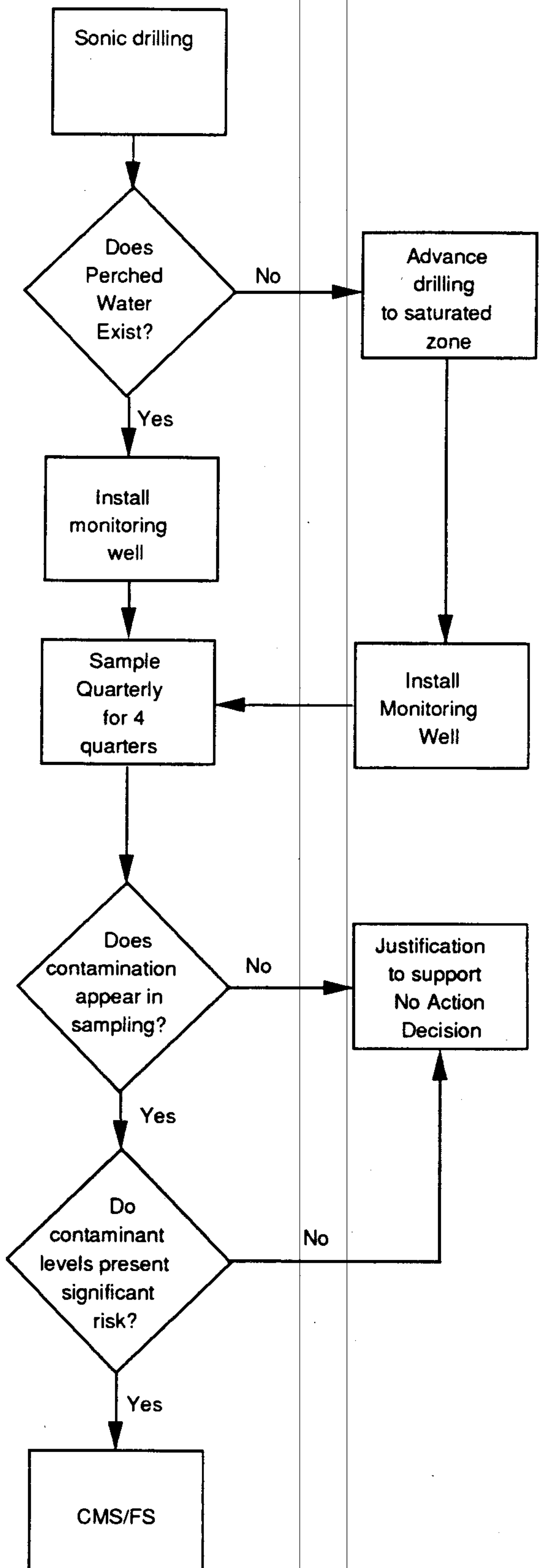
Table 4-1
SUMMARY OF MODIFICATIONS TO THE ORIGINAL OU 11 FSP

ORIGINAL FSP	MODIFIED FSP	JUSTIFICATION FOR MODIFICATION
Review new data	Statistically analyze data, compare constituents with RFP background data	Data should be compared statistically with background data to determine further need to analyze media and certain constituents
Radiation (FIDLER) survey	High Purity Germanium Survey	Determine if anomalous surface radiation exists and should be studied as intensively as proposed in the original field sampling plan. Also provides screening for worker safety.
Review existing and ongoing geological studies	Review all data	All site data need to be reviewed in conjunction with OU 11 to redefine the scope of the revised FSP
75 Surficial Soil Samples	38 Surficial Soil Samples	Based on historical surficial soil sampling and HPGe results, 75 samples are not necessary. Reducing the size will give a statistically defensible number of samples for assessment of risk.
48 Test Pit Samples	No Test Pit Samples	For the same reasons as listed in the surficial soil sampling category, but also to reduce the ecological damage that test pit sampling can cause. Depths that would be studied in Test Pits will be sampled at 10 borehole locations.
Unknown number of Borehole Samples (Phase II)	120 Borehole samples	Ten boreholes are proposed to provide additional site data and fill the data gap that lies in the upper portion of the upper hydrostratigraphic unit. Approximately 120 samples will be taken from the 10 boreholes.
16 Sediment Samples (surface water)	No Sediment Samples	Surface water does not exist at the West Spray Field. Furthermore, statistical comparisons to background of nearby surface water monitoring stations do not indicate contamination from OU 11.
Unknown Number of Subsurface Water Samples	10 Monitoring Wells Installed to Monitor Perched Water	If perched water is encountered during the drilling of the ten boreholes, monitoring wells will be installed to enable the collection of perched water samples.
Ecological Field Sampling	Reduced Ecological Field Sampling	Ecological field studies will be supplemented by ongoing sitewide studies.

Table 4-2
SUMMARY OF PROPOSED FIELD SAMPLING ACTIVITIES AT OU 11

ACTIVITY	PURPOSE	METHOD	ANALYTICAL PARAMETERS	SAMPLING FREQUENCY	NUMBER OF SAMPLES
GROUNDWATER SAMPLING					
Analytical Sampling	To determine if contamination exists in OU 11 groundwater due to historical spraying activities.	Standard operating procedures as discussed in Section 4.	Nitrates Uranium Plutonium Americium Tritium TAL Metals TCL VOCs TCL semi-VOCs	Ten groundwater monitoring wells to be sampled initially and quarterly thereafter	40 annual samples (four quarterly samples of ten groundwater monitoring wells)
Water Content	To determine if perched water zones exist above the saturated zone.	Field measurement methods using "Speedy Soil Moisture Tester" or gravimetric methods and subsequent laboratory analysis.	Percentage Measurement	Samples for water content measurement will be collected every two feet to 12 feet and every six feet thereafter	120
Water Quality	To detect abnormal conditions in groundwater.	Field analysis methods	pH specific conductance temperature dissolved oxygen barometric pressure	Ten groundwater monitoring wells to be sampled initially and quarterly thereafter	40 annual samples(four quarterly samples of six groundwater monitoring wells)
SOIL SAMPLING					
Surface Soil Samples	To determine the extent of contamination in surface soils from historical spraying activities.	EMD-OP-GT.8	Uranium 233/234, 235, 236, and 238 Plutonium Americium Tritium TAL Metals Nitrates	once	38
Sediment Samples/ Boreholes	To provide subsurface, geologic, lithologic, and analytical data.	Sonic drilling will be employed, and core samples will be collected in a split spoon sampler or by using the core barrel method.	TAL metals Uranium 233/234, 235, 236, 238 Plutonium Americium Tritium TCL VOCs TCL semi-VOCs	Two-foot composite samples form the surface to a depth of 12 feet; six foot samples from 12 feet to the saturated zone	Approximately 120

FIGURE 4-3 DRILLING LOGIC DIAGRAM



This section consists of the Quality Assurance (QA) information for the combined phases RFI/RI investigation at OU 11. Information presented herein supplements the Rocky Flats Plan Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities or QAPjP (EG&G, 1992b) and the Quality Assurance Addendum Section (Section 10) of the original OU 11 Work Plan (EG&G, 1992a).

The FSP detailed in this TM addresses the procedures for conducting the proposed field activities as well as the proposed analytical suites for the samples collected during the field investigation. This portion of the FSP identifies QA objectives for data collection, analytical procedures, calibration, and data reduction, validation and reporting. All field and analytical procedures will be performed in accordance with the methods described in the QAPjP and SOPs unless otherwise specified in this FSP.

5.1 Internal QC Control Samples

The objective of the QAPjP is to provide a framework to ensure that all sampling and analytical data achieve specific data quality standards. These standards ensure that PARCC parameters for the data are known and documented. All samples sent for Contract Laboratory Program (CLP) analyses will be handled in accordance with CLP guidelines. Quality Control (QC) procedures for non-CLP methods will be developed as needed using standard methods.

QC samples will be collected in conjunction with the investigative samples to provide information on data quality. Equipment rinsate blanks, field duplicates, laboratory blanks, laboratory replicates, and laboratory matrix spike and matrix-spike duplicates will be collected. Trip blanks will be included in sample shipments which contain samples for VOC analysis.

Rinsate blanks will be collected by pouring deionized water through decontaminated sample-collection equipment and will be submitted for the same analyses as the investigative samples. Rinsate blanks monitor the effectiveness of decontamination procedures.

Field duplicates will be collected and analyzed to provide information regarding the natural variability of the sampled media as well as evaluate analytical precision. Table 5-1 presents the suggested field QC sample collection frequency.

Analytical procedures and conditions are tested using laboratory blanks and replicates. Laboratory matrix spikes and matrix-spike duplicates measure analytical accuracy by providing data on matrix effects/interferences and components interfering with instrument responses. The frequency of collection and analysis of laboratory QC samples is dictated by the prescribed analytical method as cited in the GRRASP (EG&G, 1990).

5.2 Accuracy

Accuracy is a measure of the closeness of a reported concentration to the true value. Analytical accuracy is expressed as percent recovery of a spike of a known concentration that has been added to an environmental sample before analysis. The control limits that have been established to achieve accuracy objectives for CLP Level IV data are outlined in Appendix B of the QAPjP (EG&G 1992b). Accuracy limits for inorganic analytes are listed in this table as well. The OU 11 QC criterion for acceptable percent recovery in CLP Level IV data is 80 percent to 120 percent for all analytes in all media. Samples requiring 24- hour turnaround (that is, indicator parameter analyses) have accuracy objectives consistent with CLP Level II data quality. The analyses for indicator parameters are non-CLP. Non-CLP analyses will be conducted according to SW-846 (EPA 1990). The accuracy criteria for these samples are specified in the respective methods.

5.3 Precision

Precision is a quantitative measure of variability that is evaluated by comparing analytical results for real samples to analytical results for corresponding duplicate samples. Analytical precision for a single analyte is expressed as the Relative Percent Difference (RPD) between results of duplicate samples (and matrix spike duplicates) for a given analyte. RPDs indicate the degree of reproducibility of both the sampling and analysis methods. The control limits that have been established to achieve precision objectives for CLP Level IV data are outlined in Appendix B of the QAPjP (EG&G 1992b). Precision limits for inorganic analytes are outlined in this Appendix as well. The analysis for indicator parameters are non-CLP. Non-CLP analyses will be conducted according to SW-846 (EPA 1990). The precision criteria for these samples are specified in the respective methods. For the OU 11 data, acceptable RPDs are less than 20 percent for all analytes in water and less than 35 percent for all analytes in soils.

5.4 Sensitivity

Sensitivity defines the lowest concentration (detection limit) that a method can accurately and repeatedly detect for a particular chemical or compound. The required detection limits for CLP analyses are outlined in Table B-1 of Appendix B in the QAPjP (EG&G 1992b). Detection limits for non-CLP indicator parameter analyses shall be those specified in the respective EPA methods.

5.5 Representativeness

Representativeness is a qualitative measure of data quality defined by the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or in this case, an environmental condition. Representativeness is ensured through the careful development and review of the sampling strategy outlined in the FSP and SOPs for sample collection, analysis and field data collection.

5.6 Data Comparability

Comparability is a qualitative measure defined by the confidence with which one data set can be compared to another. Differences in field and laboratory procedures greatly affect comparability. Comparability is ensured by implementation of the FSP, standardized analytical protocols, SOPs for field investigations, and by reporting data in uniform units.

5.7 Completeness

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system (EG&G 1992c). The target completeness objective for both field and analytical data for this project is 90 percent.

5.8 Sample Management

Good sample management is a critical component of the OU 11 investigation. It ensures that sample integrity is maintained from sampling through analysis. Sample management, including labelling, sampling, decontamination, preservation/storage, chain of custody and shipping will be conducted in accordance with applicable SOPs, unless otherwise modified as necessary. Table 5-2 lists the types of containers, preservation and holding times for samples and/or sample suites for each media.

5.9 Data Reporting

Field data will be collected and reported as outlined in SOP FO.14, Field Data Management. Laboratory data from the 24-hour turnaround samples will be reported in a facsimile transmittal to the on-site manager and EG&G personnel or their designees, in order to facilitate decision making for the observational sampling approach. An electronic transmittal, in the Rocky Flats Environmental Database System (RFEDS) format, will subsequently be sent to EG&G or their designees for input into the OU 11 database. The EPA CLP sample results will be reported as specified in the GRRASP and the RFP "Specifications for Providing the Electronic Deliverable Lab Data to the Rocky Flats Environmental Data Management System (EG&G 1991)."

Table 5-1
Field QA/QC Sample Collection Frequency

Activity	Frequency
Field Duplicate[1]	1 in 10
Field Preservation Blanks	1 sample per shipping container (or a minimum of 1 per 20 samples)
Equipment Rinsate Blank	1 in 20 or 1 per day [2]
Triplicate Samples (benthic samples) [3]	For each sampling site
Source Water Blanks	1 sample per source
Trip Blanks[4]	1 per shipping container carrying VOC samples

1. For samples to be analyzed for inorganics.
2. One equipment rinsate blank in twenty samples or one per day, whichever is more frequent, for each specific sample matrix being collected when non-dedicated equipment is being used.
3. For samples collected for tissue analysis.
4. VOC sampling.

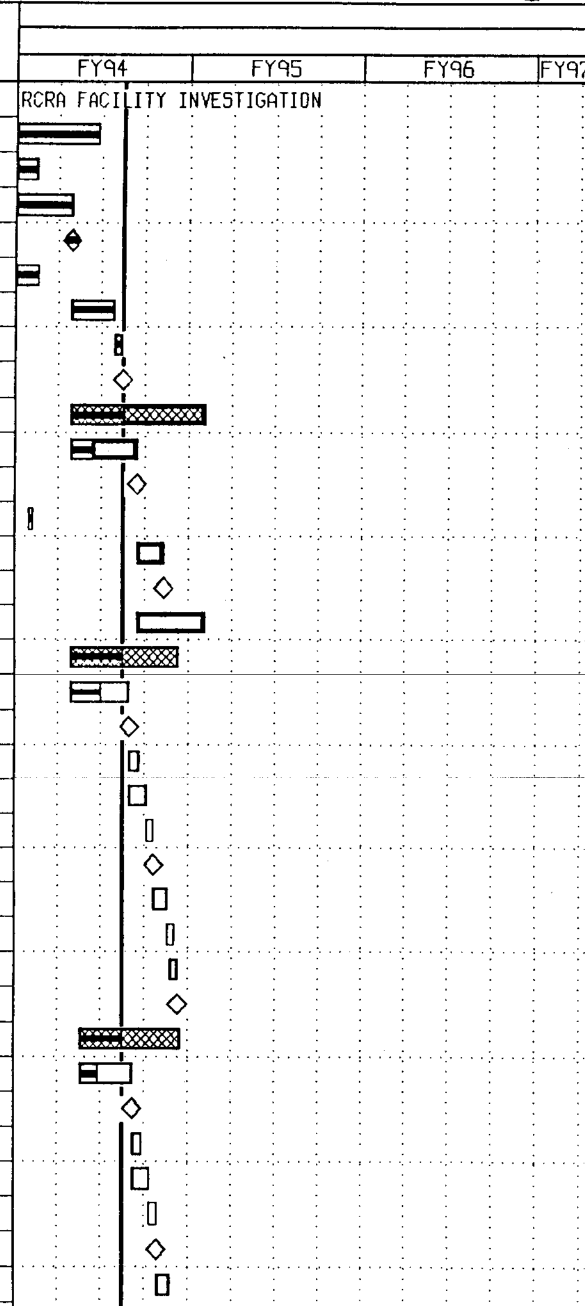
TABLE 5-2
SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR OU 11 SAMPLES

MATRIX	PARAMETER	CONTAINER	PRESERVATIVE	HOLDING TIME
SOIL	TAL Metals	1X8 oz. wide-mouth glass jar	none	6 months (28 days for mercury)
	Nitrate/Nitrite	8 oz. wide mouth glass with Teflon®-lined closure	H_2SO_4, pH<2	28 days
	TCL Volatiles	1 X 125 ml wide-mouth Teflon lined jar	Cool, 4 degrees C out of sunlight	7 days
	TCL Semivolatiles	1 X 250 ml wide-mouth Teflon-lined jar	Cool, 4 degrees C out of sunlight	7 days until extraction, 40 days after extraction
	Radionuclides	500 mL wide-mouth glass jar	none	none
WATER	TCL Volatiles	40 ml amber glass bottle with TFE silicon septa	Cool, 4 degrees C, out of sunlight	7 days
	TCL Semivolatiles	1 liter amber glass bottle with Teflon lined closure	Cool, 4 degrees C, out of sunlight	7 days until extraction; 40 days after
	Nitrate/Nitrite	2 L/P, glass	1:1 Sulfuric Acid, pH<2, Cool, 4 degrees C	28 days
	Radionuclides	3 X 4 L plastic containers (for full suite)	HNO_3	6 months
	TAL Metals	1 X 1 L polyethylene bottle	nitric acid pH<2	6 months

6.0
SCHEDULE

The schedule for the OU 11 project is presented on the following four pages.

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	REM DUR	EARLY START	EARLY FINISH	TOTL FLT
1251000002	NEPA DOCUMENTATION ACTIVITIES	36	0	1OCT93A	25MAR94A	
1251000004	EE FIELDWORK AND ANALYSES	32	0	1OCT93A	15NOV93A	
1251010010	OU 11 RFI/RI SUBCONTRACT PROCUREMENT	60	0	1OCT93A	28JAN94A	
1251010015	AWARD OU 11 RFI/RI SUBCONTRACT	0	0		28JAN94A	
1251020006	INCORPORATE DOE COMMENTS AND REVISE FSP TM	39	0	1OCT93A	19NOV93A	
1251020007	EPA/CDH REVIEW FSP TM	42	0	27JAN94A	28APR94A	
1251020008	INCORPORATE EPA/CDH COMMENTS AND REVISE FSP TM	9	0	29APR94A	13MAY94A	
1251020009	REVISED FIELD SAMPLING PLAN APPROVED	0	0	17MAY94	16MAY94	20
1251030018	OU 11 COMBINED PHASES FIELDWORK & LAB ANALYSIS	196	120	28JAN94A	3NOV94	0
1251030020	OBTAIN PERMITS & MOBILIZE	30	20	28JAN94A	14JUN94	0
1251030025	BEGIN COMBINED PHASES FIELDWORK OU 11	0	0		14JUN94	721
1251030030	RAD SURVEY	5	0	1NOV93A	7NOV93A	
1251030040	IMPLEMENTATION OF TECHNICAL MEMORANDUM (FSP)	40	40	15JUN94	10AUG94	0
1251030045	COMPLETE OU 11 COMBINED PHASES FIELDWORK	0	0		10AUG94	681
1251030046	OU 11 LAB ANALYSIS	100	100	15JUN94	3NOV94	0
1251040078	TECM MEMO #1 (EXPOSURE SCENERIO)	157	81	28JAN94A	9SEP94	156
1251040080	PREPARE TM #1(EXPOSURE SCENERIO)	21	10	28JAN94A	31MAY94	156
1251040085	SUBMIT DRAFT TM #1 TO DOE	0	0		31MAY94	156
1251040090	EG&G REVIEW TM #1	15	15	1JUN94	21JUN94	167
1251040100	DOE REVIEW TM #1	26	26	1JUN94	7JUL94	156
1251040110	REVISE TM #1	10	10	8JUL94	21JUL94	156
1251040115	SUBMIT DRAFT TM #1 TO EPA/CDH	0	0		21JUL94	156
1251040118	AGENCY REVIEW TM #1	20	20	22JUL94	18AUG94	156
1251040120	PREPARE RESPONSE SUMMARY TM #1	10	10	19AUG94	1SEP94	156
1251040130	FINAL REVISION TM #1	10	10	26AUG94	9SEP94	156
1251040135	SUBMIT FINAL TM #1 TO EPA/CDH	0	0		9SEP94	156
1251050138	TECH MEMO #2 (MODELING)	146	85	18FEB94A	15SEP94	152
1251050140	PREPARE TM #2 (MODELING)	21	14	18FEB94A	6JUN94	152
1251050145	SUBMIT DRAFT TM #2 TO DOE	0	0		6JUN94	152
1251050150	EG&G REVIEW TM #2	15	15	7JUN94	27JUN94	163
1251050160	DOE REVIEW TM #2	26	26	7JUN94	13JUL94	152
1251050170	REVISE TM #2	10	10	14JUL94	27JUL94	152
1251050175	SUBMIT DRAFT TM #2 TO EPA/CDH	0	0		27JUL94	152
1251050180	AGENCY REVIEW TM #2	20	20	28JUL94	24AUG94	152



Activity Classification: SUMMARY
RAMOCK

Plot Date 2JUN94
Data Date 17MAY94
Project Start 1OCT91
Project Finish 7MAY97

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

11FP

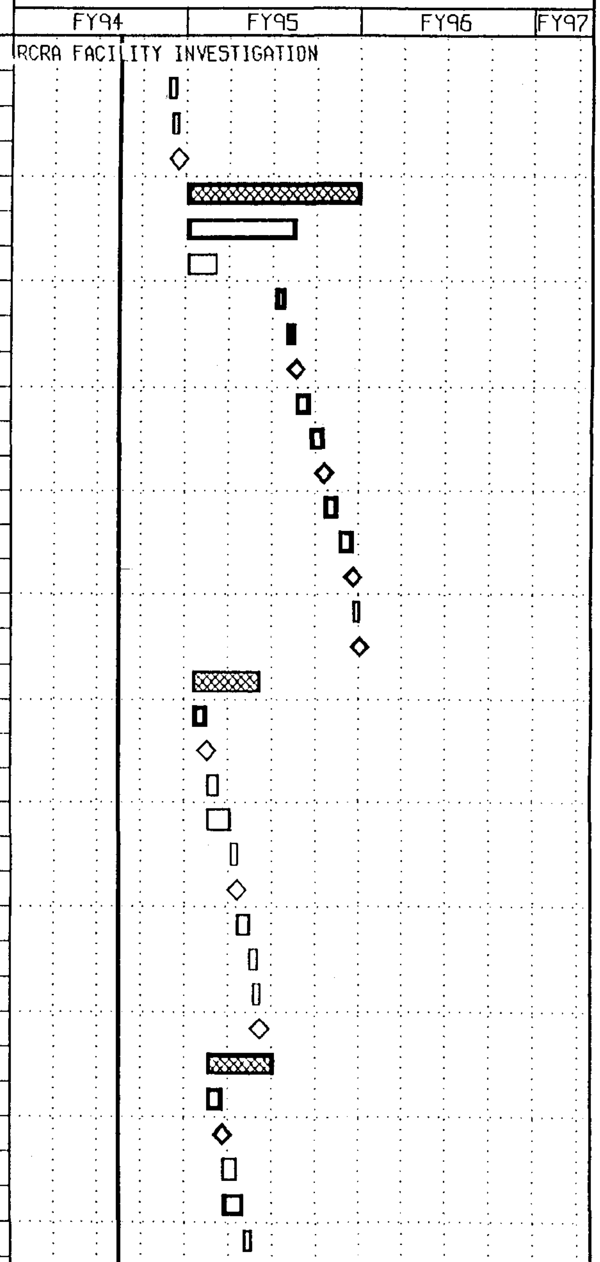
Sheet 1 of 4

EG&G ROCKY FLATS

ADS 1261/OU11 - WEST SPRAY FIELD

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	REM DUR	EARLY START	EARLY FINISH	TOTL FLT
1251050190	PREPARE RESPONSE SUMMARY TM #2	10	10	25AUG94	8SEP94	152
1251050200	FINAL REVISION TM #2	10	10	1SEP94	15SEP94	152
1251050205	SUBMIT FINAL TM #2 TO EPA/CDH	0	0		15SEP94	152
1251060048	OU 11 RFI/RI REPORT	248	248	5OCT94	3OCT95	0
1251060050	PREPARE DRAFT RFI/RI REPORT	154	154	5OCT94	19MAY95	0
1251060070	ENVIRONMENTAL EVALUATION	40	40	7OCT94	5DEC94	112
1251060347	CONDUCT HHRA	15	15	7APR95	28APR95	0
1251060348	BASELINE RISK ASSESSMENT	15	15	1MAY95	19MAY95	0
1251060350	SUBMIT DRAFT RFI/RI REPORT TO DOE	0	0	22MAY95	19MAY95	0
1251060355	DOE REVIEW DRAFT RFI/RI REPORT	21	21	22MAY95	20JUN95	0
1251060360	REVISE DRAFT RFI/RI REPORT	21	21	21JUN95	20JUL95	0
1251060365	SUBMIT RFI/RI REPORT TO EPA/CDH	0	0	21JUL95	20JUL95	0
1251060370	AGENCY REVIEW DRAFT RFI/RI REPORT	21	21	21JUL95	18AUG95	0
1251060375	REVISE DRAFT RFI/RI REPORT	21	21	21AUG95	19SEP95	0
1251060380	SUBMIT FINAL RFI/RI REPORT	0	0	20SEP95	19SEP95	0
1251060385	EPA/CDH REVIEW RFI/RI FOR FINAL APPROVAL	10	10	20SEP95	3OCT95	0
1251060387	RFI/RI REPORT APPROVED	0	0	4OCT95	3OCT95	0
1251080208	TECH MEMO #3 (CONTAMINANTS OF CONCERN)	92	92	20OCT94	8MAR95	36
1251080210	PREPARE DRAFT TM #3	21	21	20OCT94	17NOV94	0
1251080215	SUBMIT DRAFT TM #3 TO DOE	0	0		17NOV94	36
1251080220	EG&G REVIEW TM #3	15	15	18NOV94	12DEC94	47
1251080230	DOE REVIEW TM #3	26	26	18NOV94	4JAN95	36
1251080240	REVISE TM #3	10	10	5JAN95	18JAN95	36
1251080245	SUBMIT DRAFT TM #3 TO EPA/CDH	0	0		18JAN95	36
1251080250	AGENCY REVIEW TM #3	20	20	19JAN95	15FEB95	36
1251080260	PREPARE RESPONSE SUMMARY TM #3	10	10	16FEB95	1MAR95	36
1251080270	FINAL REVISION TM #3	10	10	23FEB95	8MAR95	36
1251080275	SUBMIT FINAL TM #3 TO EPA/CDH	0	0		8MAR95	36
1251090278	PREPARE DRAFT TM #4 (TOXICITY)	92	92	18NOV94	6APR95	0
1251090280	PREPARE DRAFT TM #4 (TOXICITY)	21	21	18NOV94	20DEC94	0
1251090285	SUBMIT DRAFT TM #4 TO DOE	0	0		20DEC94	0
1251090290	EG&G REVIEW TM #4	15	15	21DEC94	18JAN95	11
1251090300	DOE REVIEW TM #4	26	26	21DEC94	2FEB95	0
1251090310	REVISE TM #4	10	10	3FEB95	16FEB95	0



Activity Classification: SUMMARY

Plot Date 2JUN94
Data Date 17MAY94
Project Start 1OCT91
Project Finish 7MAY97

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Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

11FP

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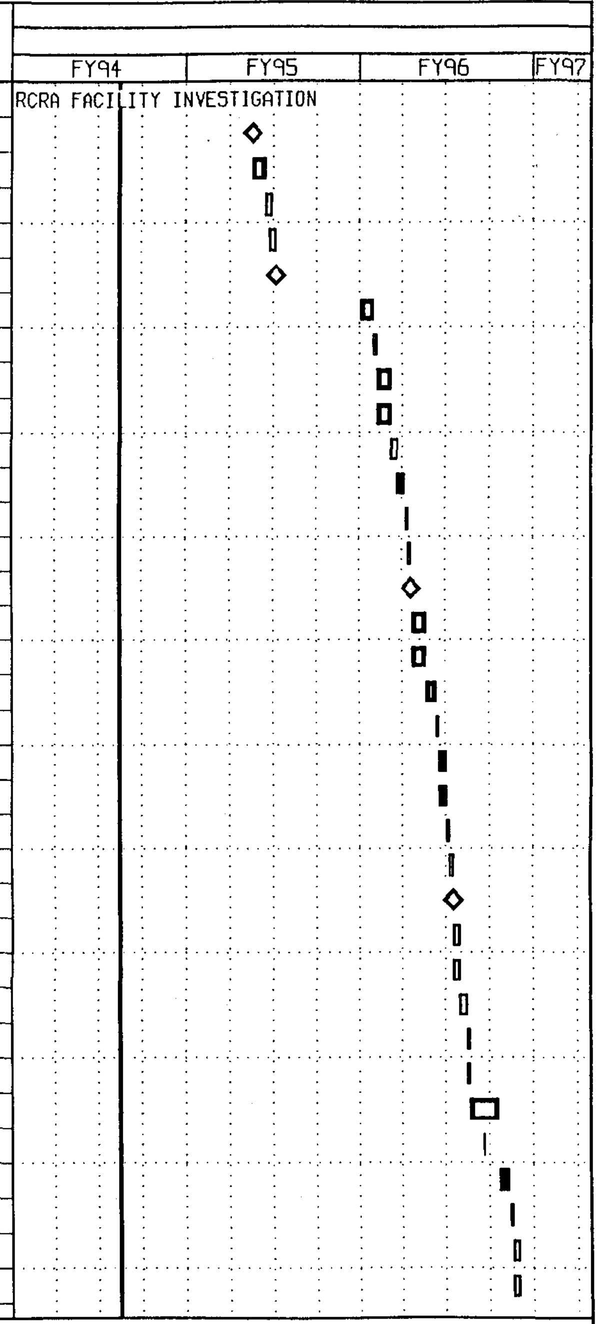
EG&G ROCKY FLATS

ADS 1261/OU11 - WEST SPRAY FIELD

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	REM DUR	EARLY START	EARLY FINISH	TOTL FLT
1251090315	SUBMIT DRAFT TM #4 TO EPA/CDH	0	0		16FEB95	0
1251090320	AGENCY REVIEW TM #4	20	20	17FEB95	16MAR95	0
1251090330	PREPARE RESPONSE SUMMARY TM #4	10	10	17MAR95	30MAR95	0
1251090340	FINAL REVISION TM #4	10	10	24MAR95	6APR95	0
1251090345	SUBMIT FINAL TM #4 TO EPA/CDH	0	0		6APR95	0
12510C1570	PREPARE PRELIMINARY DRAFT PROPOSED PLAN	20	20	4OCT95	31OCT95	0
12510C1580	DOCUMENT PROCESSING & TRANSMITTAL	5	5	1NOV95	7NOV95	0
12510C1590	DOE/RFO REVIEW DRAFT PROPOSED PLAN	20	20	8NOV95	7DEC95	0
12510C1600	DOE-HQ REVIEW DRAFT PROPOSED PLAN	20	20	8NOV95	7DEC95	0
12510C1610	INC COMMENTS AND FINALIZE DRAFT PROPOSED PLAN	10	10	8DEC95	21DEC95	0
12510C1620	DOCUMENT PROCESSING & TRANSMITTAL	5	5	22DEC95	5JAN96	0
12510C1625	2nd DOE REVIEW DRAFT PROPOSED PLAN	5	5	8JAN96	12JAN96	0
12510C1627	INCORPORATE COMMENTS	5	5	15JAN96	19JAN96	0
12510C1630	SUBMIT DRAFT PROPOSED PLAN	0	0		19JAN96	0
12510C1640	EPA/CDH REVIEW DRAFT PROPOSED PLAN	21	21	22JAN96	19FEB96	0
12510C1650	NRDA TRUSTEES REVIEW DRAFT PROPOSED PLAN	21	21	22JAN96	19FEB96	0
12510C1660	INCORPORATE COMMENTS & FINALIZE PROPOSED PLAN	15	15	20FEB96	11MAR96	0
12510C1670	DOCUMENT PROCESSING & TRANSMITTAL	5	5	12MAR96	18MAR96	0
12510C1680	DOE-HQ REVIEW FINAL PROPOSED PLAN EA	10	10	19MAR96	2APR96	0
12510C1690	DOE-RFO REVIEW FINAL PROPOSED PLAN EA	10	10	19MAR96	2APR96	0
12510C1700	INCORPORATE COMMENTS & FINALIZE PROPOSED PLAN EA	5	5	3APR96	9APR96	0
12510C1710	DOCUMENT PROCESSING & TRANSMITTAL	5	5	10APR96	16APR96	0
12510C1720	SUBMIT FINAL PROPOSED PLAN	0	0		16APR96	0
12510C1730	EPA/CDH REVIEW FINAL PROPOSED PLAN EA	10	10	17APR96	30APR96	0
12510C1740	NRDA TRUSTEES REVIEW FINAL PROPOSED PLAN EA	10	10	17APR96	30APR96	0
12510C1750	INCORPORATE COMMENTS & FINALIZE PROPOSED PLAN	10	10	1MAY96	14MAY96	0
12510C1755	PLACE ADD	5	5	15MAY96	21MAY96	0
12510C1760	DOCUMENT PROCESSING & TRANSMITTAL	5	5	15MAY96	21MAY96	0
12510C1770	PUBLIC COMMENT PERIOD - PROPOSED PLAN EA	41	41	22MAY96	19JUL96	0
12510C1775	PUBLIC HEARINGS	1	1	20JUN96	20JUN96	20
12510C1780	INCORPORATE COMMENTS PROPOSED PLAN	15	15	22JUL96	9AUG96	0
12510C1781	DOCUMENT PROCESSING & TRANSMITTAL	5	5	12AUG96	16AUG96	0
12510C1783	DOE-RFO REVIEW FINAL PROPOSED PLAN EA	10	10	19AUG96	30AUG96	0
12510C1785	DOE-HQ REVIEW FINAL PROPOSED PLAN EA	10	10	19AUG96	30AUG96	0



Activity Classification: SUMMARY
WAYMOCK

Plot Date 2JUN94
Data Date 17MAY94
Project Start 1OCT91
Project Finish 7MAY97

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

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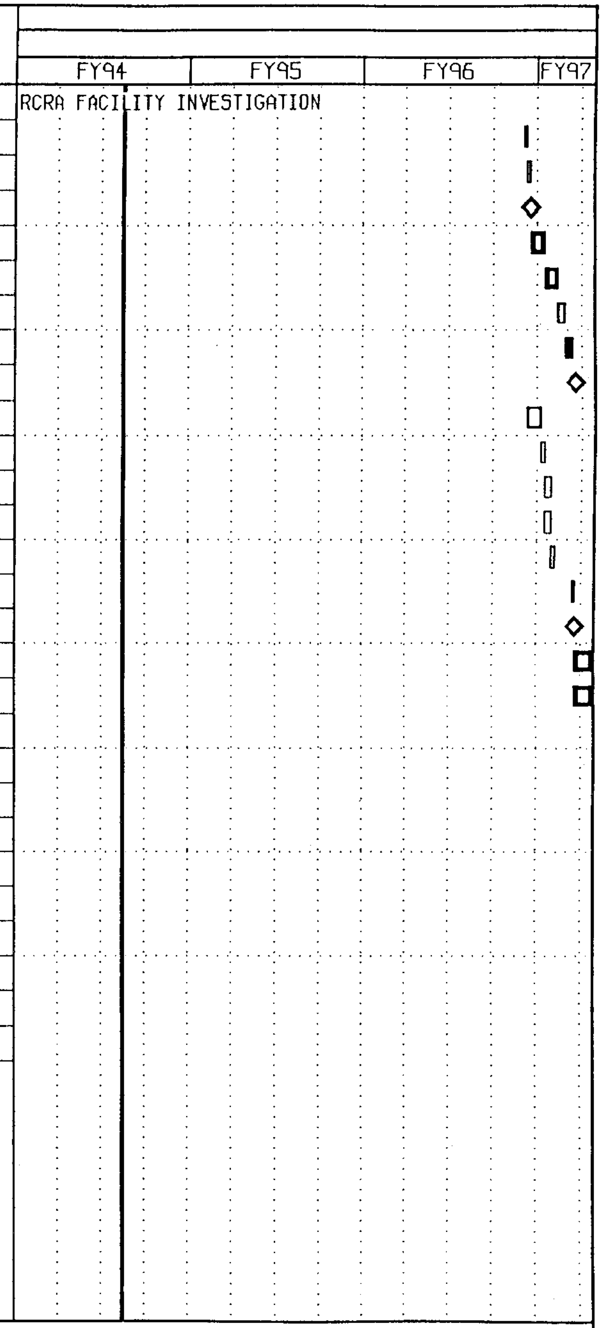
EG&G ROCKY FLATS

ADS 1261/OU11 - WEST SPRAY FIELD

Date	Revision	Checked	Approved

ACTIVITY ID	ACTIVITY DESCRIPTION	ORIG DUR	REM DUR	EARLY START	EARLY FINISH	TOTL FLT
12510C1787	INCORPORATE COMMENTS & FINALIZE PROPOSED PLAN EA	5	5	3SEP96	9SEP96	0
12510C1789	DOCUMENT PROCESSING & TRANSMITTAL	5	5	10SEP96	16SEP96	0
12510C1790	SUBMIT DRAFT RESPONSIVENESS SUMMARY	0	0		16SEP96	0
12510C1800	DOE/EPA/CDH REVIEW DRAFT RESPONSIVENESS SUMMARY	21	21	17SEP96	15OCT96	0
12510C1810	RESOLVE ISSUES & FINALIZE RESPONSIVNESS SUMMARY	20	20	16OCT96	12NOV96	0
12510C1813	DOE REVIEW RESPONSIVNESS SUMMARY	10	10	13NOV96	26NOV96	0
12510C1816	INCORPORATE COMMENTS	10	10	27NOV96	12DEC96	0
12510C1820	SUBMIT FINAL RESPONSIVENESS SUMMARY	0	0		19DEC96	0
12510C1860	PREPARE PRELIMINARY DRAFT CAD/ROD	20	20	10SEP96	7OCT96	24
12510C1870	DOCUMENT PROCESSING & TRANSMITTAL	5	5	8OCT96	14OCT96	24
12510C1880	DOE-RFO REVIEW DRAFT CAD/ROD	10	10	15OCT96	28OCT96	24
12510C1890	DOE-HQ/NEPA REVIEW DRAFT CAD/ROD	10	10	15OCT96	28OCT96	24
12510C1900	INCORPORATE COMMENTS & FINALIZE DRAFT CAD/ROD	7	7	29OCT96	6NOV96	24
12510C1910	DOCUMENT PROCESSING & TRANSMITTAL	5	5	13DEC96	19DEC96	0
12510C1920	SUBMIT DRAFT CAD/ROD	0	0		19DEC96	0
12510C1930	EPA/CDH REVIEW DRAFT CAD/ROD	21	21	20DEC96	27JAN97	0
12510C1940	NRDA TRUSTEES REVIEW DRAFT CAD/ROD	21	21	20DEC96	27JAN97	0
12510C1950	INCORPORATE COMMENTS & FINALIZE CAD/ROD	15	15	28JAN97	17FEB97	0
12510C1960	DOCUMENT PROCESSING & TRANSMITTAL	5	5	18FEB97	24FEB97	0
12510C1970	DOE-RFO REVIEW FINAL CAD/ROD	10	10	25FEB97	10MAR97	0
12510C1980	DOE-HQ/NEPA REVIEW FINAL CAD/ROD	10	10	25FEB97	10MAR97	0
12510C1990	INCORPORATE COMMENTS & FINALIZE CAD/ROD	5	5	11MAR97	17MAR97	0
12510C2000	DOCUMENT PROCESSING & TRANSMITTAL	5	5	18MAR97	24MAR97	0
12510C2010	SUBMIT FINAL CAD/ROD	0	0		24MAR97	0
12510C2020	EPA/CDH REVIEW & APPROVE FINAL CAD/ROD	21	21	25MAR97	23APR97	0
12510C2030	NRDA TRUSTEES REVIEW & APPROVE FINAL CAD/ROD	21	21	25MAR97	23APR97	0
12510C2040	RELEASE RESPONSIVENESS SUMMARY TO PUBLIC	10	10	24APR97	7MAY97	0



Activity Classification: SUMMARY
RFtOCK

Plot Date	2JUN94
Data Date	17MAY94
Project Start	1OCT91
Project Finish	7MAY97

Activity Bar/Early Dates
Critical Activity
Progress Bar
Milestone/Flag Activity

11PP

Sheet 4 of 4

EG&G ROCKY FLATS

ADS 1261/OU11 - WEST SPRAY FIELD

Date	Revision	Checked	Approved

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APPENDIX A

SUMMARY OF LIQUID SAMPLING RESULTS FOR THE SOLAR EVAPORATION PONDS

Table A-1
SUMMARY OF LIQUID SAMPLING RESULTS FOR THE
SOLAR EVAPORATION PONDS

COMPOUND	UNITS	207 B NORTH	207 B CENTER
		1984-1988 Range	1984-1988 Range
ANIONS			
Ammonia	ppm	NA	NA
Bicarbonate	ppm	NA	NA
Carbonate	ppm	NA	NA
Chloride	ppm	NA	NA
Cyanide, Total	ppm	NA	NA
Fluoride	ppm	NA	NA
Nitrate, N	ppm	212-1367	ND-1220
Nitrite	ppm	NA	NA
Phosphate, Ortho	ppm	NA	NA
Phosphate, Total	ppm	NA	NA
Sulfate	ppm	NA	NA
Sulfide	ppm	NA	NA
TKN-N	ppm	NA	NA
RADIONUCLIDES			
Americium-241	pCi/l	ND	NA
Plutonium-239	pCi/l	ND	NA
Uranium-234	pCi/l	50-53	NA
Uranium-235	pCi/l	NA	NA
Uranium-238	pCi/l	31-33	NA
Uranium	pCi/l	NA	NA
Tritium	pCi/l	1200-1300	NA
METALS			
Aluminum	ppm	ND-1.00	ND-2.00
Antimony	ppm	ND	ND
Arsenic	ppm	ND	ND
Barium	ppm	ND-0.22	ND
Beryllium	ppm	ND-0.06	ND
Bismuth	ppm	ND	ND
Boron	ppm	0.09-0.31	0.071-0.67
Cadmium	ppm	ND-0.01	ND-0.01
Calcium	ppm	20-290	2.9-95
Cerium	ppm	ND	ND
Cesium	ppm	ND	ND-0.35
Cobalt	ppm	ND	ND

NA = Not Analyzed
ND = Not Detected (below detection limits)
ppm = parts per million

Table A-1
SUMMARY OF LIQUID SAMPLING RESULTS FOR THE
SOLAR EVAPORATION PONDS

COMPOUND	UNITS	207 B NORTH	207 B CENTER
		1984-1988 Range	1984-1988 Range
Chromium, Total	ppm	ND	ND
Chromium, Hexavalent	ppm	NA	NA
Copper	ppm	ND	ND-0.037
Germanium	ppm	ND	ND
Iron	ppm	ND-0.29	ND-0.2
Lead	ppm	ND-0.004	ND-0.002
Lithium	ppm	0.37-6	0.052-3.5
Magnesium	ppm	66-120	3.9-91
Manganese	ppm	ND-0.015	ND-0.022
Mercury	ppm	ND	ND
Molybdenum	ppm	ND-0.0069	0.004-0.037
Nickel	ppm	ND-0.05	ND-0.016
Niobium	ppm	ND	ND
Phosphorous	ppm	ND	ND-0.2
Potassium	ppm	56-120	30-110
Rubidium	ppm	ND	ND
Selenium	ppm	ND-0.024	ND-0.019
Silicon	ppm	ND-5.6	1.4-5.5
Silver	ppm	ND-0.082	ND-0.015
Sodium	ppm	363-820	67-800
Strontium	ppm	0.14-3.5	0.14-0.52
Tantalum	ppm	ND	ND
Tellurium	ppm	ND	ND
Thallium	ppm	ND	ND
Thorium	ppm	ND	ND
Tin	ppm	ND	ND
Titanium	ppm	ND	ND
Tungsten	ppm	ND	ND
Vanadium	ppm	ND	ND-0.0081
Zirconium	ppm	ND	ND-0.004
Zinc	ppm	ND-0.022	ND-0.041

NA = Not Analyzed
ND = Not Detected (below detection limits)
ppm = parts per million

APPENDIX B

MATHEMATICAL ANALYTICAL MODEL

APPENDIX B

MATHEMATICAL ANALYTICAL MODEL

West Spray Field, Rocky Flats Plant

Project Objective

The objective of this groundwater project is to evaluate the influence of spray application on the water table underlying the West Spray Field of Rocky Flats Plant (RFP). This paper presents an analytical two dimensional model which has been applied to the West Spray Field parameters.

Background

For a period of approximately 4 1/2 years, from April, 1982 to October, 1985, spray irrigation was employed to evaporate RFP waste water. The West Spray Field, which was identified as a RCRA hazardous waste management unit in 1986, includes an area of approximately 105 acres. Initially, application was performed using two moving irrigation lines mounted on metal wheels; later these portable lines were replaced by fixed lines.

Three areas received irrigation. The location and size of the three areas as well as the approximate location of the fixed lines are shown in Figure 1-1 in Section 1 of this Technical Memorandum. According to recent estimates, approximately 66,000,000 gallons of waste water were applied at variable rates of 0 to 450 gallons per minute. The width of each spray line was 80 feet.

Geologic/Hydrogeologic Setting

The West Spray Field is situated on top of the Rocky Flats Alluvium unconfined aquifer. This heterogeneous alluvial fan deposit is composed of gravel, sand, and clay layers and lenses. The overall thickness of the formation in the West Spray Field area is approximately 70 feet, and the average depth to water is approximately 50 feet. However, historical and recent drilling data in the West Spray Field area have revealed that one or more perched water layers are present. This study will model the configuration of one such perched mound.

The Rocky Flats Alluvium has been pump tested in other areas of Rocky Flats. Hydraulic conductivities from those tests were assumed to be representative and were used in the analytical model.

Analytical Model

The analytical model was derived from a paper entitled "Hydrodynamics of Perched Mounds", (Brock 1976) in which models for transient and steady state mound development are presented. Equations for three basin shapes: strip, circular, and square, are given; equations representing the strip basin steady state solution were applied to the West Spray Field Area 1. The physical model consists of a shallow subsurface groundwater mound developing on top of a clay layer within the Rocky Flats Alluvium aquifer.

Hydrologic Assumptions

The following assumptions are inherent to the analytical solutions:

1. Only saturated flow occurs within the perched mound.
2. The material above the semipervious layer is homogeneous and isotropic.
3. The pressure distribution is hydrostatic within the perched mound.
4. The pressure is atmospheric just below the semipervious layer.
5. Recharge to the aquifer was applied uniformly and at a constant rate over the recharge basin.

Analytical Solution Equations

Although there is no exact analytical solution for the steady state model presented by Brock, there is a close approximation consisting of five equations. Solving the equations yields values of the maximum height and lateral extent of the mound for a set of input parameters. The five equations and definition of symbols are presented below.

eq 1.) $a = (p_0' - K_L') - (K_L'/b')H_0'$

a is calculated in terms of H_0' and substituted into equation 2.

eq 2.) $(H_0'^2 - a)^{3/2} + 3/2\ b'\ (H_0'^2 - a) = 3/2\ (b'/K_L')\ a^2$

The value of H_0' is found and substituted into equation 3.

eq 3.) $H'^2 = H_0'^2 - a\ x'^2$

Equation 3 is solved for $H' = H_1'$; $x' = x/L = 1$

eq 4.) $H' = 1/6\ (K_L'/b')\ (c - x')^2 - (3/2)\ b'$

The value of H_1' determined in equation 3 and the value of $x' = 1$ are used in equation 4 to determine a value for c.

eq 5.) $x'_{max} = c - 3\ (b'/K_L')^{1/2}$

Equation 5 yields x'_{max}. With H_0' and c known, H' versus x' can be found.

Definition of Terms

b = thickness of semipervious layer; $b' - b/L$
H = thickness of mound; $H' = H/L$
H_0 = H at center of basin; $H_0' = H_0/L$ at $X' = 0$
H_1 = H at edge of basin; $H_1' = H_1/L$ at $x' = 1$
K = permeability above layer
K_L = permeability of layer; $K_L' = K_L/K$
L = half width of strip basin
p_0 = recharge rate for $x < L$ (volume/time/area)
x = distance from center of strip; $x' = x/L$
x'_{max}= x' at which H' = o or dimensionless length of mound.

Parameters Used

K = .445 ft./day
K_L = .004 ft./day
b = 2.5 feet
L = 400 feet
p_0 = .015 $ft^3/day/ft^2$

p_0 was estimated using the following information:

Total volume of water applied = 66,000,000 gal.

Total days applied = 547.5 (It was assumed that during the 4 1/2 years irrigation was practiced, water was applied 1/3 of the time.)

Using the information above, the average P_0 was calculated to be .0102 ft./day. However the equations were yielding invalid results when this low rate was used. By trial and error, it was determined that P_0 = .015 ft./day was the lowest rate that could be entered to the equations if the other parameters were held constant. P_0 = .015 ft./day was considered to be a reasonable average infiltration rate and was used.

Calculated Results

H_0 = 6.80 feet	H_0' = .01699	
H_1 = 0.97 feet	H_1' = .002430	
x_{max} = 409.6 feet		x'_{max} = 1.024
	a = .0002828	
	c = 1.2219	

Values for the construction of a two dimensional mound profile were calculated; the mound cross sectional profile is attached (Figure A-1). The line of section for the mound is also shown on the map of the West Spray Field in Figure 4-2 in Section 4 of this TM, corresponding with the seismic line.

Discussion of Results

The above results were calculated using assumed values for K, K_L, b, and P_0. According to this analysis, the maximum height of subsurface groundwater mound development at steady state is 6.8 feet. Two numerical analyses, one for steady state flow and one for transient flow, yielded similar results in terms of mound thickness. However in the numerical analyses, the effect of varying K and b values were also investigated. In addition, the transient numerical model included the entire West Spray Field rather than only Area 1. The significance of these studies in light of the field sampling plan is that subsurface groundwater mounds under the West Spray Field are relatively thin. Good core recovery is critical to the characterization program.

Figure B-1 East-West Profile of Mound Across Area 1

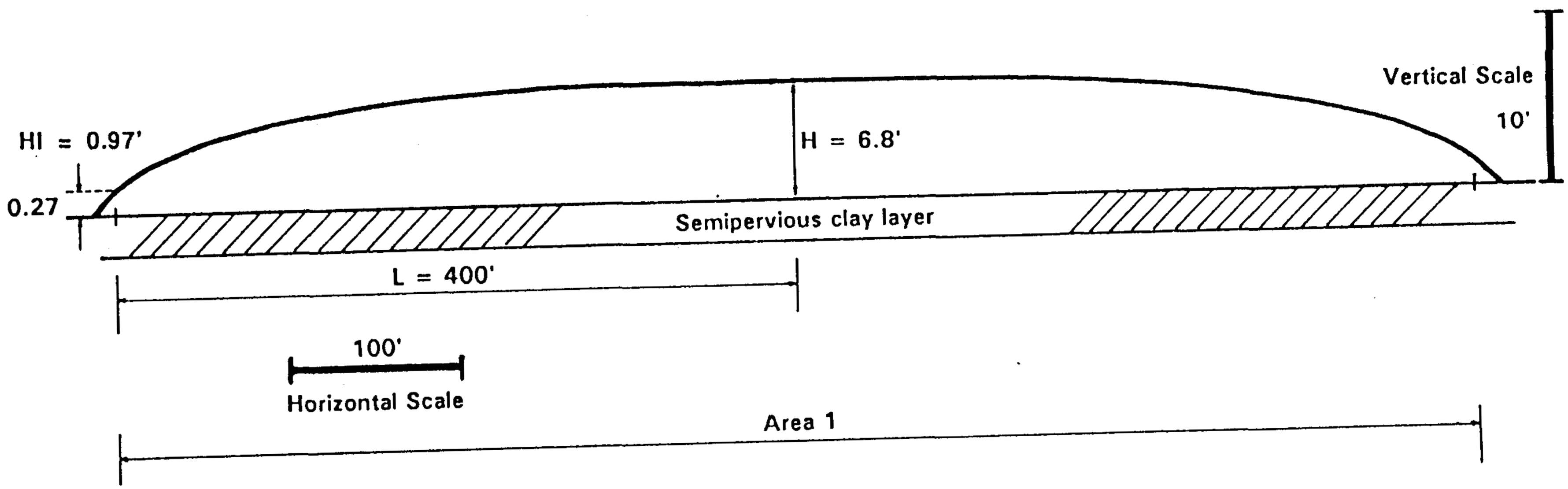


TABLE B-1 CALCULATED EAST-WEST PROFILE OF MOUND ACROSS AREA 1

Data Calculated for Mound Profile

x	x'	H'	H
(H_0)	0	.01699	6.80
50'	.125	.01686	6.74'
100'	.25	.01646	6.58'
150'	.375	.01578	6.31'
200'	.5	.01476	5.90'
250'	.625	.01334	5.34'
300'	.75	.01138	4.55'
350'	.875	.00849	3.40'
400' (H_1)	1.0	.002421	0.97
409.6' x_{max}			0

APPENDIX C

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

TABLE C-1
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
ALLUVIAL GROUNDWATER

Analytes	Units	Sample Type	OU 11 Sample No.	OU 11 Max Detected Value	OU 11 Sample Mean	Background Mean
Metals						
Aluminum	µg/L	Total	46	208,000.00	11,237.99	6,239.42
Iron	µg/L	Total	46	198,000.00	10,692.18	8,215.92
Manganese	µg/L	Total	46	2,710.00	256.33	165.77
Sodium	µg/L	Total	46	21,200.00	13,457.83	7,547.90
Antimony	µg/L	Total	46	17.20	11.28	21.15
Arsenic	µg/L	Total	45	1.80	1.29	1.20
Barium	µg/L	Total	46	1,040.00	108.82	123.20
Beryllium	µg/L	Total	46	16.40	1.33	0.82
Cadmium	µg/L	Total	46	1.30	1.24	1.22
Calcium	µg/L	Total	46	62,200.00	23,390.22	34,036.84
Chromium	µg/L	Total	46	208.00	14.04	14.43
Cobalt	µg/L	Total	46	68.00	7.04	5.02
Copper	µg/L	Total	46	191.00	11.15	12.49
Lead	µg/L	Total	46	59.80	4.57	6.58
Lithium	µg/L	Total	46	134.00	12.97	8.79
Magnesium	µg/L	Total	46	37,000.00	6,156.93	5,295.26
Molybdenum	µg/L	Total	46	3.80	15.02	2.90
Nickel	µg/L	Total	46	155.00	15.46	14.16
Potassium	µg/L	Total	46	25,200.00	2,045.11	1,455.35
Silicon	µg/L	Total	33	135,000.00	23,336.36	13,100.00
Silver	µg/L	Total	46	9.40	1.87	1.73
Strontium	µg/L	Total	45	252.00	126.96	133.54
Thallium	µg/L	Total	46	1.00	1.15	0.65
Tin	µg/L	Total	46	39.40	23.26	11.64
Vanadium	µg/L	Total	46	349.00	21.28	17.29
Zinc	µg/L	Total	46	405.00	32.29	64.73
Aluminum	µg/L	Dissolved	42	1,030.00	64.02	201.92
Antimony	µg/L	Dissolved	46	26.30	12.71	15.33
Barium	µg/L	Dissolved	46	87.20	51.05	68.01
Calcium	µg/L	Dissolved	46	39,400.00	21,841.96	32,205.60
Chromium	µg/L	Dissolved	46	3.10	2.22	4.78
Cobalt	µg/L	Dissolved	46	6.50	4.83	3.94
Copper	µg/L	Dissolved	46	2.30	2.73	4.05
Iron	µg/L	Dissolved	43	1,730.00	105.30	221.75
Lead	µg/L	Dissolved	46	1.50	0.81	1.58
Lithium	µg/L	Dissolved	45	7.10	8.94	7.64
Magnesium	µg/L	Dissolved	46	9,820.00	4,469.57	4,102.23
Manganese	µg/L	Dissolved	46	1,380.00	88.67	7.59

NOTE:
The calculated sample mean incorporates each non-detect as a value equal tohalf the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

TABLE C-1
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
ALLUVIAL GROUNDWATER

Analytes	Units	Sample Type	OU 11 Sample No.	OU 11 Max Detected Value	OU 11 Sample Mean	Background Mean
Mercury	µg/L	Dissolved	46	0.24	0.11	0.10
Nickel	µg/L	Dissolved	46	5.70	5.31	6.33
Potassium	µg/L	Dissolved	46	1,360.00	773.15	657.27
Selenium	µg/L	Dissolved	46	1.60	0.85	16.06
Silicon	µg/L	Dissolved	33	14,300.00	10,838.79	8,614.58
Sodium	µg/L	Dissolved	46	20,800.00	13,124.57	7,611.54
Strontium	µg/L	Dissolved	46	236.00	122.88	265.56
Tin	µg/L	Dissolved	46	11.20	22.24	19.04
Vanadium	µg/L	Dissolved	45	3.90	4.97	5.10
Zinc	µg/L	Dissolved	46	19.10	4.69	17.48
Mercury	µg/L	Total	46	0.24	0.11	0.11
Selenium	µg/L	Total	45	1.00	0.86	1.00
Arsenic	µg/L	Dissolved	46	0.80	1.22	1.06
Radionuclides						
Gross Alpha	pCi/L	Dissolved	42	14.88	1.28	0.60
Uranium-233,234	pCi/L	Dissolved	38	7.74	0.57	0.18
Uranium-238	pCi/L	Dissolved	38	6.76	0.44	0.13
Gross Beta	pCi/L	Dissolved	46	6.96	1.75	1.83
Strontium-89,90	pCi/L	Dissolved	46	1.30	0.34	0.26
Uranium-235	pCi/L	Dissolved	38	0.28	0.04	0.03
Americium-241	pCi/L	Total	42	0.16	0.01	0.00
Cesium-137	pCi/L	Total	31	0.86	0.09	0.13
Plutonium-239,240	pCi/L	Total	41	0.25	0.01	0.00
Tritium	pCi/L	Total	46	1,535.00	146.39	362.50
WQ Parameters						
Chloride	mg/L		35	15.00	7.50	5.24
Fluoride	mg/L		46	2.50	0.55	0.77
Nitrate/Nitrite	mg/L		46	7.30	1.69	1.51
Sulfate	mg/L		46	35.60	11.89	24.17
Cyanide	mg/L		42	0.00	0.00	0.01

NOTE:
The calculated sample mean incorporates each non-detect as a value equal tohalf the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

TABLE C-2
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
BEDROCK GROUNDWATER

Analytes	Units	Sample Type	OU 11 Sample No.	OU 11 Max Detected Value	OU 11 Sample Mean	Background Mean
Metals						
Barium	µg/L	Total	8	289.00	167.50	374.87
Chromium	µg/L	Total	8	41.30	25.35	272.23
Aluminum	µg/L	Total	8	15,300.00	5,852.48	2,546.67
Arsenic	µg/L	Total	8	3.60	1.88	4.60
Cadmium	µg/L	Total	8	1.10	1.16	1.45
Calcium	µg/L	Total	8	67,000.00	36,737.50	34,583.33
Cobalt	µg/L	Total	8	10.30	4.38	273.02
copper	µg/L	Total	8	20.00	7.91	300.06
Iron	µg/L	Total	8	14,000.00	6,278.00	3,619.13
Lead	µg/L	Total	8	15.00	5.06	5.38
Lithium	µg/L	Total	8	26.60	16.74	46.83
Magnesium	µg/L	Total	8	11,100.00	6,997.50	6,945.00
Manganese	µg/L	Total	8	331.00	170.25	179.23
Molybdenum	µg/L	Total	8	53.10	28.03	276.14
Nickel	µg/L	Total	8	40.10	23.11	285.58
Potassium	µg/L	Total	8	5,060.00	4,170.00	3,216.67
Selenium	µg/L	Total	8	1.30	0.76	1.08
Silicon	µg/L	Total	8	38,400.00	18,300.00	8,905.00
Sodium	µg/L	Total	8	44,800.00	29,400.00	172,350.00
Strontium	µg/L	Total	8	484.00	369.88	420.50
Tin	µg/L	Total	8	15.20	12.13	20.38
Vanadium	µg/L	Total	8	63.30	26.44	288.32
Zinc	µg/L	Total	8	84.50	35.94	368.88
Aluminum	µg/L	Dissolved	8	31.80	14.46	42.16
Antimony	µg/L	Dissolved	8	10.00	9.55	14.97
Arsenic	µg/L	Dissolved	8	2.20	1.48	3.56
Barium	µg/L	Dissolved	8	144.00	88.40	68.17
Calsium	µg/L	Dissolved	7	33,300.00	28,187.50	33,752.63
Cesium	µg/L	Dissolved	8	30.00	83.57	88.34
Iron	µg/L	Dissolved	8	210.00	35.06	26.08
Lithium	µg/L	Dissolved	8	26.30	11.84	49.11
Magnesium	µg/L	Dissolved	8	7,790.00	3,808.00	6,276.32
Manganese	µg/L	Dissolved	8	171.00	54.21	8.40
Molybdenum	µg/L	Dissolved	8	52.70	27.41	18.15
Potassium	µg/L	Dissolved	8	4,230.00	3,000.00	3,379.74
Selenium	µg/L	Dissolved	8	1.20	0.68	1.97
Silicon	µg/L	Dissolved	8	4,470.00	3,835.00	3,536.67
Sodium	µg/L	Dissolved	8	44,800.00	29,525.00	194,115.79

NOTE:
The calculated sample mean incorporates each non-detect as a value equal to half the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

TABLE C-2

SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES

BEDROCK GROUNDWATER

Analytes	Units	Sample Type	OU 11 Sample No.	OU 11 Max Detected Value	OU 11 Sample Mean	Background Mean
Strontium	µg/L	Dissolved	8	462.00	313.38	450.40
Thallium	µg/L	Dissolved	8	1.00	0.78	1.37
vanadium	µg/L	Dissolved	8	25.00	13.04	7.47
Zinc	µg/L	Dissolved	8	4.30	2.73	11.88
Radionuclides						
Gross Alpha	pCi/L	Dissolved	7	2.60	1.49	3.37
Gross Beta	pCi/L	Dissolved	8	4.47	3.37	4.02
Radium-226	pCi/L	Dissolved	2	0.30	0.23	2.98
Strontium-89, 90	pCi/L	Dissolved	8	1.09	0.43	0.38
Uranium-233, 234	pCi/L	Dissolved	6	1.50	0.47	1.83
Uranium-235	pCi/L	Dissolved	6	0.18	0.06	0.05
Uranium-238	pCi/L	Dissolved	6	1.10	0.30	0.57
Americium-241	pCi/L	Total	7	0.01	0.00	0.01
Cesium-137	pCi/L	Total	5	0.58	0.23	0.00
Plutonium-239, 240	pCi/L	Total	6	0.03	0.01	0.00
Tritium	pCi/L	Total	8	352.60	123.51	400.00
WQ Parameters						
Chloride	mg/L		7	13.00	6.43	103.03
Fluoride	mg/L		8	1.40	1.05	1.20
Nitrate/Nitrite	mg/L		8	0.03	0.02	1.21
Sulfate	mg/L		8	128.00	56.69	203.88

NOTE:
The calculated sample mean incorporates each non-detect as a value equal to half the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

TABLE C-3
SUMMARY STATISTICS AND BACKGROUND COMPARISON TABLES
SURFACE SOILS

Analytes	Sample Units	OU 11 Sample Number	OU 11 Max Detected Value	OU 11 Sample Mean	Background Mean
Metals					
Lead	mg/kg	12	26.00	16.15	36.02
Mercury	mg/kg	12	not available	0.18	not available
Radionuclides					
Gross Alpha	pCi/g	12	30.00	11.67	10.75
Gross Beta	pCi/g	12	38.00	23.50	33.31
Plutonium - 239/240	pCi/g	12	0.59	0.15	not applicable
Uranium - 233, 234	pCi/g	12	1.30	0.93	1.22
Uranium - 238	pCi/g	12	1.40	0.91	1.32
Other					
Nitrate/Nitrite	mg/kg	12	60.00	14.43	2.26

NOTE:
The calculated sample mean incorporates each non-detect as a value equal to half the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

TABLE C-4

SUMMARY STATISTICS AND BACKGROUND COMPARISON FOR OU 11

SUBSURFACE SOILS

Analytes	Sample Units	Sample Number	Max Detected Value	Sample Mean	Background Mean
Metals					
Lead	mg/kg	24	24.00	12.51	8.82
Mercury	mg/kg	22	0.46	0.16	0.18
Radionuclides					
Gross Alpha	pCi/g	24	39.00	12.88	21.82
Gross Beta	pCi/g	23	36.00	24.83	23.89
Plutonium - 239/240	pCi/g	23	0.25	0.03	0.00
Uranium, Total	pCi/g	24	3.00	1.89	1.28
Uranium-233, 234	pCi/g	24	1.60	0.99	0.64
Uranium - 238		24	1.40	0.94	0.63
Other					
Nitrate/Nitrite	mg/kg	22	150.00	36.36	1.08

NOTE:

The calculated sample mean incorporates each non-detect as a value equal to half the detection limit. For compounds having high detection limits, the value of the mean may exceed the maximum detected value.

APPENDIX D

ECOLOGICAL SAMPLING TABLES

Table D-1
ECOLOGICAL FIELD SAMPLING ACTIVITIES

TAXON	SPRAYED AREAS		NON-SPRAYED AREAS		REFERENCE AREAS		TOTAL SAMPLES	
	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED
GRIDS NEEDED (5x5)	4	4	4	4	4	4	12	12
TERRESTRIAL								
BIOTA								
Vegetation Cover (5/grid)	20	20	20	20	20	20	60	60
Vegetation Belt Transects (5/grid)	20	20	20	20	20	20	60	60
Vegetation Quadrats (5/grid)	20	20	20	20	20	20	60	60
Arthropods (1/grid)	4	4	4	4	4	4	12	12
Birds (5, 2-ha plots x 6 replicates, 500-m transect)	30 for entire area				30 for area		60	60
(#of grids x 25 traps x 3 trap nights)	300	300	300	300	300	300	900	900
Large Mammals:								
Pellet Counts	4	0 (a)	4	0 (a)	4	0 (a)	12	0 (a)
Relative Abundance	1	1	1	1	1	1	3	3
TISSUE								
grids x 3 replicates; 25-g sample)	12	12	12	12	12	12	36	36
Small Mammals (1/species/grid)	4	0 (b)	4	0 (b)	4	0 (b)	12	0 (b)
Arthropods (1, 25-g/site)	1	0 (b)	1	0 (b)	1	0 (b)	12	0 (b)

Table D-1
ECOLOGICAL FIELD SAMPLING ACTIVITIES

TAXON	SPRAYED AREAS		NON-SPRAYED AREAS		REFERENCE AREAS		TOTAL SAMPLES	
	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED	PROPOSED	COMPLETED
AQUATIC	**Surface Water Pond #128**				**Lindsay Pond**			
BIOTA								
5 replicates per species								
Zoobenthos (quantitative)	1	1						
Zoobenthos (qualitative)	5	0 (c)			5	0 (c)	10	0 (c)
Periphyton	5	0 (c)			5	0 (c)	10	0 (c)
Phytoplankton	5	0 (c)			5	0 (c)	10	0 (c)
Zooplankton	5	0 (c)			5	0 (c)	10	0 (c)
TISSUE								
3 replicates, 25-g sample/taxon								
Periphyton	3	0 (b)			2	0 (b)	5	0 (b)
Macrophyte	3	0 (b)			2	0 (b)	5	0 (b)
Zoobenthos (not expected)	3	0 (b)			2	0 (b)	5	0 (b)
Benthos (3 replicates x 3 species)	9	0 (b)			9	0 (b)	18	0 (b)
REPTILES & AMPHIBIANS								
TISSUE								
5 replicates, 25-g samples								
Anurans	3	0 (b)			3	0 (b)	6	0 (b)
Uropods	3	0 (b)			3	0 (b)	6	0 (b)
CRUSTACEANS								
TISSUE	3	0 (b)			3	0 (b)	6	0 (b)

(a) Scheduled for Spring, 1994.

(b) Sample collection depends on preliminary data, problem formulation, and Agency guidance.

(c) Preliminary sampling results under EcMP and preliminary exposure assessment indicate that the SW-128 site may not be in the contaminant pathway from OU-11 except perhaps during high flow runoff events. Tentatively scheduled for sampling during Spring, 1994.

Table D-2
OU 11 DATA FROM THE
ECOLOGICAL MONITORING PROGRAM STUDIES

	SPRAYED AREAS	NON-SPRAYED AREAS	REFERENCE AREAS	TOTAL SAMPLES
TERRESTRIAL				
Soil Invertebrates				
a) Arthropods 0-5 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
b) Arthropods 5-10 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
c) Nematodes 0-5 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
d) Nematodes 5-10 cm	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
Soil Functions	20+4 QA/QC	20+4 QA/QC	20+4 QA/QC	72
Soil Physical/Chemical	20	20	20	60
Plant Tissue	6	6	6	18
Litter	6	6	6	18
AQUATIC				
Emergent Insects	15		29	44
Zoobenthos (qualitative)	1		1	2
Zoobenthos (quantitative)	3		6	9
Phytoplankton	3		10	13
Zooplankton	3		11	14
Water Chemistry	8		10	18

APPENDIX E

STATISTICAL JUSTIFICATION FOR THE REVISED OU 11 SURFACE SOIL SAMPLING PLAN

APPENDIX E
STATISTICAL JUSTIFICATION FOR THE REVISED OU 11 SURFACE SOIL SAMPLING PLAN

The agency approved methodology for statistically comparing site to background data to identify site contamination, referred to as the Gilbert test methodology, consists of six statistical test including the Slippage test, Quantile test, Wilcoxon Rank Sum (WRS) test, Gehan test, t-test (if the data are normally distributed), and a hot measurement test (EG&G, 1994). At the present time, no statistical methodology exists for determining the combined power of the entire Gilbert test methodology to detect site contamination given a specified number of samples from both the site and background areas. However, a methodology does exist for determining the power of two of the tests, the Quantile and WRS tests, to detect site contamination and is presented in *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3*, (Gilbert and Simpson, 1992). This methodology was used to estimate the number of samples necessary to compare surface soil data from Operable Unit 11 (OU 11) to background. The objective of this approach was to determine the most resource-effective sampling design to satisfy DQOs.

The statistical methodology presented in the original FSP-TM preceded the Gilbert methodology and the EPA guidance document on the DQO process. In the second version of the FSP-TM, an approach was presented based on qualitative statistical discussions indicating that the original sample size could be reduced due the nature of contamination likely present at OU 11. Neither of these methodologies were incorrect, however, they are being abandoned in favor of an approach more consistent with current EPA guidance.

To determine the sample size necessary to achieve a specified power, we must specify the variability of the populations to be compared, the minimum detectable difference, Type I error rate, and the statistical test to be used. Any sample size calculations will be specific to these conditions and will not apply if they change. Therefore, sample size calculations based upon normally distributed data and a simple t-test will not correctly predict the sample size necessary to achieve the same level of power using non-normally distributed data and the nonparametric tests specified in the Gilbert methodology.

Sample size calculations were performed for two of the nonparametric tests (Quantile and Wilcoxon Rank Sum) specified in the Gilbert test methodology. The Wilcoxon Rank Sum (WRS) test is equivalent to the Gehan test when only one detection limit for nondetected values is reported in the data. Evaluating the performance of these tests provides a means of estimating the power of the Gilbert test methodology to detect site contamination at OU 11. The combined power of the entire Gilbert test methodology to detect contamination should be greater than the individual power of any single test. Therefore, these calculations represent conservative estimates of the power of the Gilbert test methodology to detect contamination at OU 11.

The Quantile and WRS tests are designed to detect different types of site contamination. When a small area of the site contains high levels of contamination (e.g., three standard deviations above the mean), the Quantile test will have more power than the WRS test to detect this contamination. However, when the level of contamination is small (e.g., one standard deviation above the mean) and the contamination is widespread throughout the site, the WRS test will have more power than the Quantile test. The use of both tests is recommended to detect both types of contamination (Gilbert and Simpson, 1992). However, the use of both tests does increase the probability of incorrectly determining contamination exists when it actually does not.

The null and alternative hypotheses for the Quantile and WRS tests are stated as (Gilbert and Simpson, 1992):

H_o: Reference-Based Cleanup Standard Achieved

H_a: Reference-Based Cleanup Standard Not Achieved

The hypotheses stated above are the opposite of those used to compare site data to risk-based cleanup standards or ARARs. This approach was adopted because stating the null hypothesis as the reference-based standard has not been achieved would require most site measurements to be less than reference measurements before determining that the standard has been achieved. The hypotheses stated above were also used in USEPA (1989, p.4-8) to test for differences between contaminant concentrations in a reference area and a site of interest.

The Type I error rate (α) for this test is defined as the probability of incorrectly determining that the site exceeds background. The Type II error rate (β) is defined as the probability of incorrectly determining that the site does not exceed background when it actually does. The Type I and Type II error rates were set at 0.20 and 0.05, respectively during sample size calculations for both the Quantile and WRS tests.

Sample size calculations for the WRS followed the methodology presented in Gilbert and Simpson (1992). It is assumed in these calculations that all data collected during the field program will be useable for statistical testing. The equation for calculating the number of samples to collect from the reference site and clean-up unit when the distribution of the data is unknown is:

$$N=\frac{(Z_{1-\alpha}+Z_{1-\beta})^2}{12c(1-c)(P_r-o.5)^2} \qquad (1)$$

where

N	=	total number of required samples (site plus background)
α	=	specified Type I error rate
β	=	specified Type II error rate
$Z_{1-\alpha}$	=	value that cuts off $(100\alpha)\%$ of the standard normal probability distribution
$Z_{1-\beta}$	=	value that cuts off $(100\beta)\%$ of the standard normal probability distribution
c	=	specified proportion of the total number of samples, N, that will be collected in the reference area (specified as 0.5 when one site is being compared to background)
P_r	=	specified probability greater than 1/2 and less than 1.0 that a measurement collected at a random location in the cleanup unit is greater than a measurement of a sample collected at random in the reference area (see discussion below)

A value of the probability, P_r, must be specified when calculating sample sizes for the WRS test using the equation given above. However, it may be difficult to understand what a specific value of P_r actually means in terms of the relative difference between the two populations to be detected. Rather than directly specify P_r, it may be easier to specify the relative shift (Δ/σ) in the site concentration distribution to the right (to higher values) of the reference distribution to be detected with a given power. Values of P_r for different relative shifts of the site distribution to the right of the reference distribution are given in Gilbert and Simpson (1992, p. 6.12). A relative shift of 0.95 standard deviations corresponding to a P_r of 0.75 was used during sample size calculations for the WRS test. This means that the sample size calculated will detect site concentrations greater than background when the site concentration distribution is 0.95 standard deviations to the right of the reference area concentration distribution with the power specified in the test (0.95).

Using the parameters specified above (α = 0.20, β = 0.05, and P_r = 0.75) in equation 1 results in a total sample size (site plus background) of 33. This requires 17 samples to be collected from the unit being compared to background (OU 11) and 17 samples from the background unit itself.

Sample size calculations for the Quantile test were also conducted using the methodology given in Gilbert and Simpson (1992). To determine the sample size necessary to detect site contamination with a given power, we must specify the relative shift (Δ/σ) of the site concentration distribution relative to the background concentration distribution and the percentage of the site (ϵ) that is contaminated. Tables for determining the power associated with different combinations of Δ/σ, ϵ, and α are given in Appendix A of Gilbert and Simpson (1992). Since the Quantile test is more effective than the WRS test in detecting site contamination when only a portion of the site is highly contaminated, sample size calculations were conducted for a relative shift of 3.0 standard deviations within 40 percent of the site data. Since a table was not given for a Type I error rate of 0.20, a Type I error of 0.10 was used as a conservative approximation. This resulted in a power of 0.956 for sample sizes of 20 for both the site and background data.

Summary

Sample size calculations for the WRS and Quantile test were conducted using procedures given in Gilbert and Simpson (1992). The power of each test to detect site contamination was chosen as 0.95. The combined power of the entire Gilbert test methodology to detect contamination is probably greater than the power of any of the tests individually, however, methods for addressing the power of the entire Gilbert test methodology do not exist at this time. Therefore, a more conservative approach was adopted using existing methods.

The results of the sample size calculations indicate that 20 samples are necessary to adequately characterize surface soils at OU 11. This represents a conservative estimate of the minimum sample size to meet the DQOs set forth in this document. However, based upon hydrologic consideration and our understanding of past operations at OU 11, a larger sample size of 38 was chosen. This provides enough data to meet the statistical objectives of the DQOs and provides additional protection against incorrectly determining the site is not contaminated when it actually is.

REFERENCES

Gilbert, R. O. 1994. Memo to Beverly Ramsey describing the process for implementation of the Rocky Flats Environmental Statistical Method.

Gilbert, R. O and Simpson, J. C. 1992. *Statistical methods for Evaluating the Attainment of Cleanup Standards, Vol. 3, Reference Based Standards for Soils and Solid Media.* Pacific Northwest Laboratories; Richland, Washington. December.

APPENDIX F

TAL METALS
TCL VOLATILES
TCL SEMIVOLATILES

SOIL, SEDIMENT, AND WATER SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

TABLE F-1
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Target Analyte List - Metals	Water (μg/l)	Detection Limits* Soil/Sediment (μg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1.0
Cadmium	5	1.0
Calcium	5000	2000
Cesium	1000	200
Chromium	10	2.0
Cobalt	50	10
Copper	25	5.0
Cyanide	10	10
Iron	100	20
Lead	5	1.0
Lithium	100	20
Magnesium	5000	2000
Manganese	15	3.0
Mercury	0.2	0.2
Molybdenum	200	40
Nickel	40	8.0
Potassium	5000	2000
Selenium	5	1.0
Silver	10	2.0
Sodium	5000	2000
Strontium	200	40
Thallium	10	2.0
Tin	200	40
Vanadium	50	10.0
Zinc	20	4.0

TABLE F-2
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

		Quantitation Limits*
Target Compounds List - Volatiles	**Water (μg/l)**	**Soil/Sediment (μg/kg)**
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10**	10
Chloroethane	10	10
Methylene Chloride	5	5
Acetone	10	10
Carbon Disulfide	5	5
1,1-Dichloroethene	5	5
trans 1,2-Dichloroethene	5	5
Chloroform	5	5
1,2-Dichloroethene	5	5
2-Butanone	10	10
1,1,1-Trichloroethane	5	5
Carbon Tetrachloride	5	5
Vinyl Acetate	10	10
Bromodichloromethane	5	5
1,1,2,2-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5
trans-1,3-Dichloropropane	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2-Trichloroethane	5	5
Benzene	5	5
cis-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	10	10
4-Methyl-2-penatone	10	10
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Xylenes	5	5

TABLE F-3
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Semivolatiles	Water (μg/l)	Quantitation Limits* Soil/Sediment (μg/kg)
Phenol	10**	330
bis(2-Chloroethyl)ether	10**	330
2-Chlorophenol	10**	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
Benzyl alcohol	10	330
1,2-Dichlorobenzene	10	330
2-Methylphenol	10	330
bis(2-Chloroisopropyl)ether	10	330
4-Methylphenol	10	330
N-Nitroso-di-n-propylamine	10	330
Hexachloroethane	10	330
Nitrobenzene	10**	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
Benzoic acid	50	1600
bis(2-Chloroethoxy)methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Tricholorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	10	330
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol(parachloro-meta-cresol)	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	10	330
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	50	1600
2-Chloronapthalene	10	330
2-Nitroaniline	50	1600
Dimethylphthalate	10	330
Acenaphthylene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600
Acenaphthene	10	330

TABLE F-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

		Quantitation Limits*
Semivolatiles	**Water (µg/l)**	**Soil/Sediment (µg/kg)**
2,4-Dinitrophenol	50	1600
4-Nitrophenol	50	1600
Dibenzofuran	10	330
2,4-Dinotrotoluene	10	330
Diethyphthalate	10	330
4-Cholrophenyl-phenyl ether	10	330
Flourene	10	330
4-Nitroaniline	50	1600
4,6-Dinitro-2-methylphenol	50	1600
N-nitrosodiphenylamine	10	330
4,-Bromophenyl-phenylether	10	330
Hexacholobenzene	10**	330
Pentachlorophenol	50	1600
Phenanthrene	10	330
Anthracene	10	330
Di-n-butylphthalate	10	330
Flouranthene	10	330
Pyrene	10	330
Butylbenzylphthalate	10	330
3,3'-Dichlorobenzidine	20**	660
Benzo(a)anthacene	10	330
Chrysene	10	330
bis(2-Ethylhexyl)phthalate	10	330
Di-n-octylphthalate	10	330
Benzo(b)flouranthene	10	330
Benzo(k)flouranthene	10	330
Benzo(a)pyrene	10	330
Ideno(1,2,3-cd)pyrene	10	330
Dibenz(a,h)anthracene	10	330
Benzo(g,h,i)perylene	10	330

TABLE F-4
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

		Quantitation Limits* **Required Detection Limits***
Radionuclides	**Water (pCi/L)**	**Soil/Sediment (pCi/g)**
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235 and 238 (each species)	0.6	0.3 dry
Americium 241	0.01	0.02 dry
Plutonium 239+240	0.01	0.03 dry
Tritium	400	400 (pCi/ml)

*Detection and quantitation limits are highly matrix dependent. The limits listed here are the minimum achievable under ideal conditions. Actual limits may be higher.

**The laboratory Practical Quantification Limits (PQLs) for these analytes exceed ARARs.

APPENDIX G

SONIC DRILLING PROCEDURES

APPENDIX G
RESONANT SONIC DRILLING AND SAMPLING PROCEDURES
FOR OPERABLE UNIT 11

PURPOSE AND SCOPE

This appendix describes procedures for drilling and sampling geologic media using resonant sonic drilling equipment. This equipment is proposed for use during implementation of the Combined Phases RCRA Facility Investigation/Remedial Investigation (RFI/RI) for Rocky Flats Operable Unit (OU) 11, West Spray Field.

Resonant sonic drilling equipment was chosen over more conventional drilling equipment for this project because of technical and programmatic advantages indicated in similar geologic media at other DOE facilities (Westinghouse 1993). Technical advantages include (1) generally improved sample recovery and (2) the ability to continuously sample media that includes cobbles and boulders, both of which contribute to improved lithologic characterization. Programmatic advantages include (1) a rapid rate of penetration, (2) significantly reduced drilling waste, and (3) increased speed and ease of developing monitor wells.

PERSONNEL QUALIFICATIONS

Personnel overseeing resonant sonic drilling and soil sampling will have a minimum of a B.A. or B.S. in geology or a related field and applicable field experience. The driller will have previous experience operating resonant sonic drilling equipment without the addition of drilling fluids (or air).

REFERENCES

Source References

The following is a list of references reviewed prior to writing these procedures:

- Resonant Sonic Drilling: History, Progress, and Advances in Environmental Restoration Programs. WHC-SA-1949-FP, Westinghouse Hanford Company, Richland, Washington. September 1993.

- Results of Testing the Sonic Drilling System at the Hanford Site (September 1991 to May 1992). WHC-SD-EN-TRP-002, Westinghouse Hanford Company, Richland, Washington. Not Dated.

- Technical Evaluation of Sonic Drilling for Environmental Sampling. EG&G Rocky Flats, Golden Colorado. September 1992.

- Technical Memorandum. Revised Field and Sampling Plan and Data Quality Objectives. The West Spray Field Operable Unit No. 11, Revision 1 Draft. U.S. Department of Energy, Golden, Colorado. February 2, 1994.

- Test Plan for Sonic Drilling at the Hanford Site in FY 1993. WHC-SD-EN-028, Rev. 0, Westinghouse Hanford Company, Richland, Washington. 1993.

Internal References

Standard operating procedures (SOPs) cross-referenced by this DMR include the following:

- SOP FO.3, General Equipment Decontamination
- SOP FO.4, Heavy Equipment Decontamination
- SOP FO.8, Handling of Drilling Fluids and Cuttings
- SOP FO.23, Management of Soil and Sediment Investigative Derived Materials
- SOP GT.1, Logging Alluvial and Bedrock Material
- SOP GT.2, Drilling and Sampling Using Hollow Stem Auger Techniques
- SOP GT.4, Rotary Drilling and Rock Sampling
- SOP GT.5, Plugging and Abandonment of Boreholes
- SOP GT.6, Monitoring Wells and Piezometer Installation
- SOP GT.10, Borehole Clearing

GENERAL

Resonant sonic drilling is a recently developed technology in the environmental industry that can be used in place of conventional drilling methods to obtain stratigraphic, lithologic, hydrogeologic, geotechnical, and environmental data and to install monitor wells.

Hollow-stem, continuous-flight auger techniques are conventionally used for most environmental borehole drilling and sampling because they allow continuous samples to be obtained and do not introduce drilling fluids into the geologic media. However, alluvial materials at Rocky Flats contain a high percentage of cobbles and boulders that have been problematic for hollow-stem auger techniques. Common problems include equipment failure and poor sample recovery.

Other conventional drilling methods, such as mud-rotary and air-percussion, allow borehole advancement through cobbles and boulders but do not permit collection of suitable continuous samples for chemical analysis and/or geologic characterization. Furthermore, both methods generate an overabundance of undesirable potentially hazardous drilling waste (dust, mud, and cuttings).

In contrast to conventional drilling techniques, resonant sonic techniques offer three advantages: (1) media containing cobbles and boulders can be penetrated effectively, (2) drilling fluids (including air) are not required, and (3) sample recovery is typically improved. Moreover, comparatively little drilling waste is produced. The resonant sonic drilling method combines rotation with high-frequency vibration to advance the drill string. At specified depths, the vibration is stopped and an internal core barrel containing a nearly undisturbed core sample is retrieved. This method allows continuous sampling (physical and chemical) to be achieved through media containing boulders and cobbles. These reported advantages have lead to the proposed use of resonant sonic drilling techniques at OU 11. Samples collected during resonant sonic drilling for chemical and physical characterization will be prepared in general accordance with guidelines in SOP GT.2, Drilling and Sampling Using Hollow Stem Auger Techniques. The retrieval of the sample will be achieved through drilling sampling methods outlined later in this DMR.

General Resonant Sonic Drilling and Sampling Equipment

The following is a list of equipment and materials required for resonant sonic drilling:

- Resonant sonic truck-mounted drill rig with appropriate bits and tools
- Appropriate sonic rig accessories (for example, sonic head, wire-line, pulleys, weights, leveling jacks, breakout jaws, and core barrel)
- High pressure steamer/sprayer
- Wash/rinse tubs
- Weighted tape measure
- Phosphate-free, lab-grade detergent (for example, Liquinox)
- Water-level probe
- Appropriate health and safety equipment
- Drums for containment of cuttings and fluids (see SOP FO.8, Handling of Drilling Fluids and Cuttings, and FO.23, Management of Soil and Sediment Investigative Derived Materials)
- Boring log form
- Field Activities report form
- Pint-sized plastic jars with screw caps for cuttings (see SOP GT.1, Logging Alluvial and Bedrock Material)
- Black, waterproof (permanent) marking pens
- Sampler and 6 5/8" outer diameter sampler casing
- Plastic sample sleeves or sample trays
- Stainless steel mixing bowl and utensils
- Self-adhesive labels
- Ice chests

- Decontamination brushes
- Location map
- Measuring tape
- Distilled water
- Field book
- Boring log forms
- Communication equipment

General Procedures

Boreholes will be drilled from the ground surface to the target depth using resonant sonic drilling techniques. Personnel will decontaminate all drilling and sampling equipment, including rig, drill string, and core barrel sampler before going to the work site. Because the OU 11 drilling will be conducted within the site boundary, the rig will not be decontaminated between boreholes. However, down-hole equipment will be decontaminated between each borehole, and sampling equipment will be decontaminated between each sample. The drill rig and related drilling and sampling equipment will be inspected for gross contamination and for operational integrity to guard against fuel, oil, and hydraulic leaks (see SOP FO.3, General Equipment Decontamination, and SOP FO.4, Heavy Equipment Decontamination). Identified problems will be corrected before drilling. If lubricants are required for the drilling and sampling process, only adhesiveless Teflon tape will be used.

Before drilling activities begin, the borehole locations will be established and cleared for subsurface investigation in accordance with SOP GT.10, Borehole Clearing. Cuttings and fluids generated will be handled in accordance with SOP FO.8, Handling of Drilling Fluids and Cuttings, and FO.23, Management of Soil and Sediment Investigative Derived Materials. If monitor wells are not installed, boreholes will be abandoned according to SOP GT.5, Plugging and Abandonment of Boreholes. All procedures will be conducted according to the OU 11 Health and Safety Plan.

The borings will be logged lithologically by examination and classification of the samples according to GT.1, Logging Alluvial and Bedrock Material. Detailed accounts of the subsurface encountered will be recorded by the rig geologist in the field book. This record will include, but not be limited to, time, depth, strata variation, moisture content, and first indication of free water. Daily rig activities will be recorded by the rig geologist on a field activity form (similar to SOP GT.2 form GT.2A and SOP GT.4 form GT.4A).

RESONANT SONIC DRILLING TECHNIQUES

Resonant sonic drilling is performed through a hydraulic drill head that transmits high-frequency pressure waves through steel drilling pipe to create a cutting action at the tip of the drill bit. Pressure waves are created by center-rotating, offset balanced roller-weights. The frequency of the generated waves closely match the natural frequency of the drill string, causing the column to vibrate elastically along its longitudinal axis. In this resonant condition, the drill string acts as a fly-wheel, transmitting maximum power to the drill bit. This power, combined with slow rotation (to expose fresh material to the bit) and slight downward pressure, advances the drill string through soil and rock without the need for drilling fluids or air.

Depending on the material drilled, penetration is achieved by displacement, shearing, or fracturing. Displacement occurs when the vibration of the drill bit fluidizes the soil particles and moves them out of its path. This action mainly occurs in unconsolidated, granular material that has sufficient free volume to accept the displaced material. Shearing occurs in soils that have soft and pliable characteristics, such as clay. For shearing to occur, the force and related vibratory amplitude must be great enough to overcome the elastic nature of the material. An even greater force is necessary to fragment cobbles, boulders, and bedrock surfaces. In this case, the continuous rotation of the drill string exposes fresh rock surface at the drill bit face.

Because the drilling action and design of the drill string either forces the displaced material into the wall of the borehole or into the core barrel, very small volumes of cuttings are produced.

Environmental Sampling

Soil samples will be collected in order to obtain geologic and chemical characteristics information. Sampling will be performed using a dual-line drill pipe and split core barrel sampler. Although it is possible to sample shallow (less than 30 feet) subsurface materials using a single drill pipe core barrel combination, this simpler set-up may allow slough material to be included with the recovered sample and is unacceptable for this project.

Instead, samples will be collected in a separate inner split barrel sampler resonated ahead of the outer drill pipe. The inner core sampler will be advanced using the Resonant Sonic™ method unless high temperatures, which could negatively affect chemical concentrations, are produced. If high temperatures are produced, the inner split core barrel sampler will instead be advanced using percussion techniques. The inner core barrel will be advanced and retrieved in 2- foot intervals up to 10 feet ahead of the outer drill pipe. The outer drill pipe will then be advanced to the same depth of the pre-cored hole. Any slough that may have accumulated inside the drill pipe will be retrieved using a solid slough barrel. Coring using the split core barrel sampler will then resume for the next interval. Once at the surface, the sample will be removed from the split core barrel into a plastic sleeve or clean sample tray. After a sample is collected, the core barrel will be decontaminated and prepared to retrieve the next sample.

Soil sampling procedures and sample logging from this point will take place in accordance with SOP GT.1, Logging Alluvial and Bedrock Material, and SOP GT.2, Drilling and Sampling Using Hollow Stem Auger Techniques.

Well Installation

Monitor well installation will occur in each borehole after soil sampling has been completed, provided the desired perched aquifer characteristics have been identified. Well construction will be similar to well construction with hollow-stem auger or air-percussion equipment, the exception being the method to emplace the sand filter and bentonite seals.

The space between the outer drill pipe and the well casing is too small to allow use of tremmie pipes for emplacing well construction materials. Consequently, well construction materials will be added to the hole from the surface, while the outer pipe is vibrated and pulled up allowing the material to settle. Typically, the vibration prevents the well construction materials from bridging and aids compaction of the sand filter around the well. Well construction will be completed in accordance with SOP GT.6, Monitoring Wells and Piezometer Installation.

Decontamination

Generalized equipment decontamination procedures cover both sampling and drilling equipment.

For sampling equipment, decontamination will be conducted between individual sampling points to minimize potential cross-contamination. Sampling equipment will be decontaminated in accordance with SOP FO.3, General Equipment Decontamination. During drilling and sampling, decontaminated equipment will be placed on clean plastic sheeting or racks until it is used. At least two sets of samplers will be available so that one may be used while the other is being decontaminated, unless the sampling equipment is so specialized that it is not possible to have two available.

For drilling equipment, decontamination of drill pipe, drill bits, and other down-hole equipment will be conducted after each boring has been completed. The drill rig will be decontaminated prior to entering a work area of different contaminant characterization. Decontamination of drilling equipment is described in SOP FO.4, Heavy Equipment Decontamination.

Documentation

All information required by this DMR will be documented on the Borehole Log Form (Form GT.1A) and the Resonant Sonic Drilling Field Activities Report (GT.4B). The Field Activities Report form will be filled out each day for each location visited. The borehole log will include information on subsurface material classification and lithology. Information on sample length, classification, and lithology will be recorded on the log form. The Field Activities Report will include the following information and have space for comments and documentation of general observations.

- Project name and borehole identification
- Date
- Weather conditions
- Equipment descriptions (rig, bit, etc.)
- Drilling firm and driller name
- Geologist and other crew members (with subcontractors)
- Borehole depth and diameter

- Water level
- Depth to bedrock
- Sampling types and depths
- Drilling fluid used (if any)
- Compressor/pump type (if any)
- End-of-day status (in progress or drilling complete)
- Chronological record of activities

APPENDIX H

HPGe SUMMARY TABLES

Table H-1
OU 11 HPGe RESULTS
(DRAFT)

OU	Detector Array	Detector Height (m)	FOV (m)	Station	North (feet)	East (feet)	K-40 (pCi/g)	Ra-226 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Cs-137 (pCi/g)	Am-241 (pCi/g)	Pu-239 (pCi/g)	Exposure (μR/h)	% FOV Blocked
11	4A6	6.5	44	I8	749200	2076700	7.48	0.827	1.09	1.66	0.0684	0.466	0	0	6.19	0
11	4A6	6.5	44	K8	749000	2076700	7.72	0.832	1.15	1.79	0.073	0.529	0	0	6.25	0
11	4A6	6.5	44	M8	748800	2076700	8.26	0.859	1.28	2.04	0.0775	0.556	0	0	6.67	0
11	4A6	6.5	44	O8	748600	2076700	8.41	0.846	1.31	1.96	0.0959	0.572	0	0	6.89	0
11	4A6	6.5	44	Q8	748400	2076700	7.25	0.947	1.18	2.02	0.0777	0.603	0	0	6.43	0
11	4A6	6.5	44	S8	748200	2076700	7.22	1.04	1.17	1.85	0.0628	0.648	0	0	6.69	0
11	4A6	6.5	44	U8	748000	2076700	7.34	1.03	1.21	2.02	0.0799	0.611	0	0	6.91	0
11	4A6	6.5	44	U8	748000	2076700	7.37	1.12	1.23	2.01	0.0696	0.612	0	0	6.88	0
11	4A6	6.5	44	W8	747800	2076700	6.13	0.636	0.951	1.61	0.0666	0.52	0	0	5.26	0
11	4A6	6.5	44	I10	749200	2076900	7.76	0.772	1.14	1.72	0.0786	0.497	0	0	6.24	0
11	4A6	6.5	44	K10	749000	2076900	7.6	0.812	1.15	2.05	0.0721	0.521	0	0	6.3	0
11	4A6	6.5	44	M10	748800	2076900	7.92	0.942	1.14	1.7	0.0528	0.496	0	0	6.54	0
11	4A6	6.5	44	O10	748600	2076900	7.83	1	1.22	1.98	0.0583	0.574	0	0	6.8	0
11	4A6	6.5	44	Q10	748400	2076900	5.97	0.659	0.906	1.47	0.0593	0.494	0	0	5.37	0
11	4A6	6.5	44	S10	748200	2076900	7.93	0.959	1.14	1.82	0.0518	0.628	0	0	7.43	0
11	4A6	6.5	44	U10	748000	2076900	7.04	0.957	1.14	1.91	0.0697	0.667	0	0	6.41	0
11	4A6	6.5	44	W10	747800	2076900	6.01	0.831	0.944	1.59	0.0478	0.581	0.089	0	5.56	0
11	4A6	6.5	44	W10	747800	2076900	6.51	0.789	1.03	1.65	0.0759	0.648	0	0	5.79	0
11	4A6	6.5	44	I12	749200	2077100	7.95	0.991	1.15	1.72	0.0601	0.501	0	0	6.64	0
11	4A6	6.5	44	K12	749000	2077100	7.1	0.957	1.12	1.93	0.0709	0.533	0	0	6.43	0
11	4A6	6.5	44	M12	748800	2077100	7.43	0.958	1.16	2	0.0719	0.561	0	0	6.63	0
11	4A6	6.5	44	O12	748600	2077100	7.43	0.938	1.23	1.87	0.0642	0.591	0.075	0	6.71	0
11	4A6	6.5	44	O12	748600	2077100	7.38	0.849	1.18	1.9	0.0744	0.585	0	0	6.32	0
11	4A6	6.5	44	O12	748600	2077100	7.46	0.831	1.2	1.91	0.0765	0.594	0	0	6.36	0
11	4A6	6.5	44	Q12	748400	2077100	6.11	0.646	0.914	1.33	0.0559	0.522	0	0	5.48	0

FOV = Field of View
m = meters
pCi/g = picoCuries per gram
μR/h = microRems per hour

Table H-1
OU 11 HPGe RESULTS
(DRAFT)

OU	Detector Array	Detector Height (m)	FOV (m)	Station	North (feet)	East (feet)	K-40 (pCi/g)	Ra-226 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Cs-137 (pCi/g)	Am-241 (pCi/g)	Pu-239 (pCi/g)	Exposure (μR/h)	% FOV Blocked
11	4A6	6.5	44	S12	748200	2077100	6.99	0.908	1.14	1.81	0.0702	0.697	0	0	6.44	0
11	4A6	6.5	44	U12	748000	2077100	6.53	0.913	1.09	1.79	0.0617	0.67	0	0	6.15	0
11	4A6	6.5	44	W12	747800	2077100	6.9	0.857	1.05	1.74	0.0685	0.613	0	0	6.08	0
11	4A6	6.5	44	I14	749200	2077300	6.23	0.776	0.96	1.51	0.0604	0.401	0	0	5.5	0
11	4A6	6.5	44	K14	749000	2077300	7.25	0.935	1.12	1.97	0.0488	0.502	0	0	6.32	0
11	4A6	6.5	44	M14	748800	2077300	7.2	1.06	1.16	2.16	0.0497	0.592	0.139	0	6.83	0
11	4A6	6.5	44	M14	748800	2077300	7.48	0.739	1.21	2.23	0.0714	0.626	0	0	6.35	0
11	4A6	6.5	44	O14	748600	2077300	7.21	1.08	1.11	1.88	0.0426	0.55	0	0	6.69	0
11	4A6	6.5	44	Q14	748400	2077300	6.69	0.998	1.05	1.78	0.0618	0.622	0	0	6.36	0
11	4A6	6.5	44	S14	748200	2077300	6.23	0.637	0.977	1.79	0.0727	0.578	0	0	5.37	0
11	4A6	6.5	44	U14	748000	2077300	5.66	0.613	0.9	1.42	0.0686	0.586	0	0	5.09	0
11	4A6	6.5	44	W14	747800	2077300	6.56	0.628	0.915	1.5	0.0792	0.532	0	0	5.28	0
11	4A6	6.5	44	I16	749200	2077500	8.46	0.873	1.27	2.01	0.0747	0.532	0	0	6.77	0
11	4A6	6.5	44	K16	749000	2077500	7.28	0.766	1.12	1.81	0.0723	0.48	0	0	5.98	0
11	4A6	6.5	44	M16	748800	2077500	7.33	0.869	1.22	1.96	0.0848	0.613	0	0	6.47	0
11	4A6	6.5	44	O16	748600	2077500	7.25	0.889	1.25	2.09	0.0814	0.664	0	0	6.59	0
11	4A6	6.5	44	Q16	748400	2077500	8.02	0.842	1.3	2.24	0.0962	0.669	0	0	6.88	0
11	4A6	6.5	44	S16	748200	2077500	7.67	0.83	1.25	2.12	0.0946	0.709	0	0	6.7	0
11	4A6	6.5	44	U16	748000	2077500	6.24	0.736	1.02	1.85	0.0565	0.735	0	0	5.74	0
11	4A6	6.5	44	W16	747800	2077500	6.33	0.764	1.02	1.93	0.0681	0.774	0	0	5.83	0
11	4A6	6.5	44	ORW	752000	2078120	14.7	1.21	1.76	2.41	0.0688	0.273	0	0	10.3	0
11	4A6	6.5	44	E24	749600	2078300	7.33	0.856	1.13	2.02	0.0827	0.514	0	0	6.16	0
11	4A6	6.5	44	H24	749300	2078300	6.93	0.757	1.07	1.77	0.069	0.591	0	0	5.83	0
11	4A6	6.5	44	K24	749000	2078300	6.72	0.733	0.956	1.66	0.0614	0.494	0	0	5.54	0
11	4A6	6.5	44	N24	748700	2078300	6.29	0.809	0.97	1.43	0.0567	0.565	0	0	5.91	0

FOV = Field of View
m = meters
pCi/g = picoCuries per gram
μR/h = microRems per hour

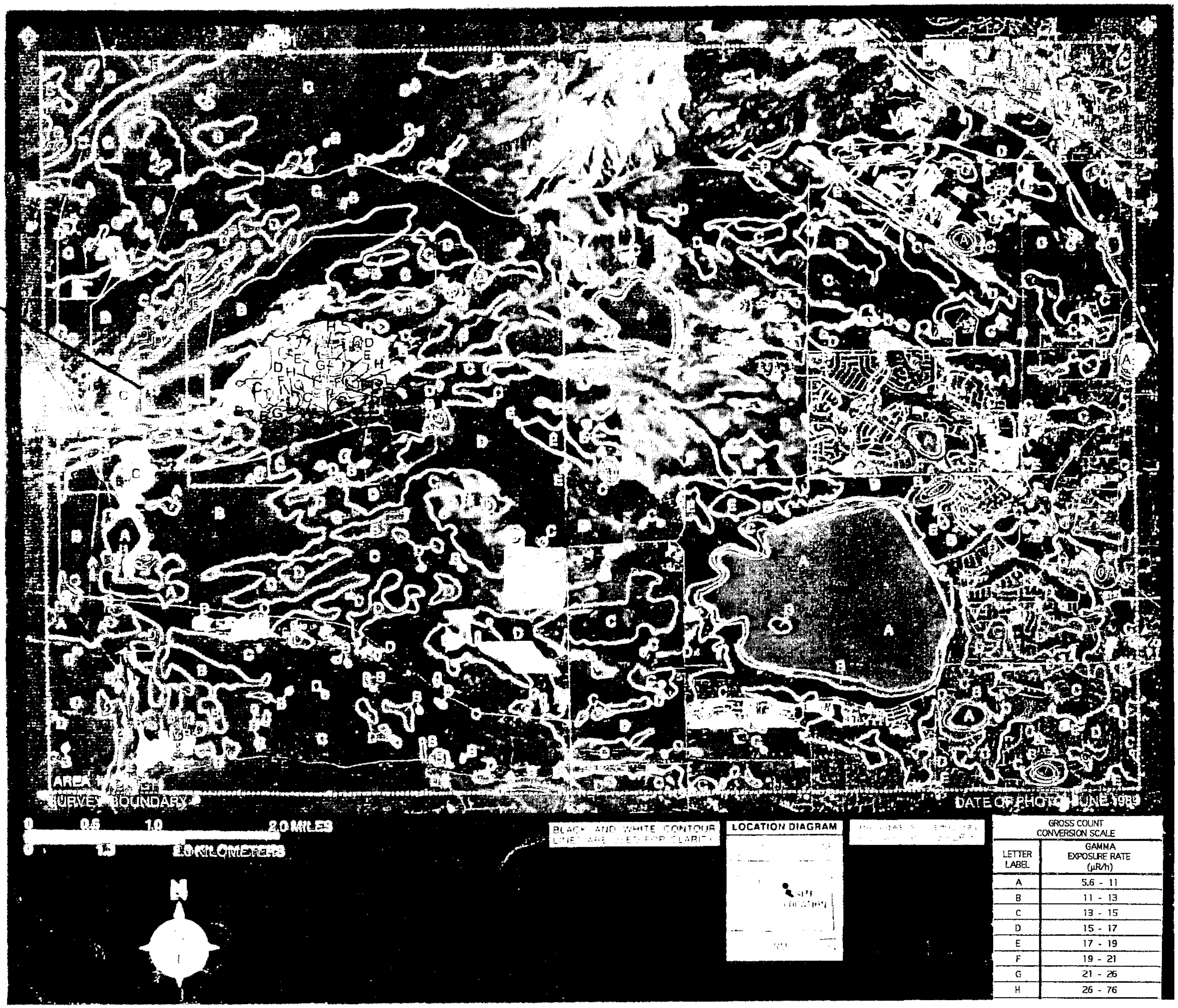
Table H-1
OU 11 HPGe RESULTS
(DRAFT)

OU	Detector Array	Detector Height (m)	FOV (m)	Station	North (feet)	East (feet)	K-40 (pCi/g)	Ra-226 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Cs-137 (pCi/g)	Am-241 (pCi/g)	Pu-239 (pCi/g)	Exposure (µR/h)	% FOV Blocked
11	4A6	6.5	44	J25	749100	2078400	7.15	0.777	1.14	1.73	0.0847	0.638	0	0	6.15	0
11	4A6	6.5	44	M25	748800	2078400	6.32	0.768	1.01	1.55	0.06	0.645	0	0	5.77	0
11	4A6	6.5	44	H26	749300	2078500	7.85	0.867	1.23	1.82	0.0795	0.657	0	0	6.72	0
11	4A6	6.5	44	F27	749500	2078600	6.15	0.781	0.909	1.41	0.0503	0.445	0	0	5.41	0
11	4A6	6.5	44	K27	749000	2078600	7.25	1.02	1.26	2.05	0.0809	0.672	0	0	6.82	0
11	4A6	6.5	44	M27	748800	2078600	6.42	1.4	1.14	1.63	0.0193	0.695	0	0	7.3	0
11	4A6	6.5	44	H28	749300	2078700	8.08	0.892	1.3	2.16	0.0802	0.66	0	0	6.95	0
11	4A6	6.5	44	J28	749100	2078700	7.29	0.855	1.2	1.98	0.0838	0.69	0	0	6.55	0
11	4A6	6.5	44	K29	749000	2078800	7.19	1.01	1.23	2.01	0.0744	0.683	0	0	6.82	0
11	4A6	6.5	44	M29	748800	2078800	6.39	1.27	1.13	1.74	0.0269	0.621	0	0	6.88	0
11	4A6	6.5	44	F30	749500	2078900	7.12	0.959	1.11	1.87	0.063	0.521	0	0	6.42	0
11	4A6	6.5	44	H30	749300	2078900	7.05	0.858	1.2	1.84	0.0897	0.674	0	0	6.39	0
11	4A6	6.5	44	J30	749100	2078900	7	0.812	1.15	1.95	0.0734	0.705	0	0	6.34	0

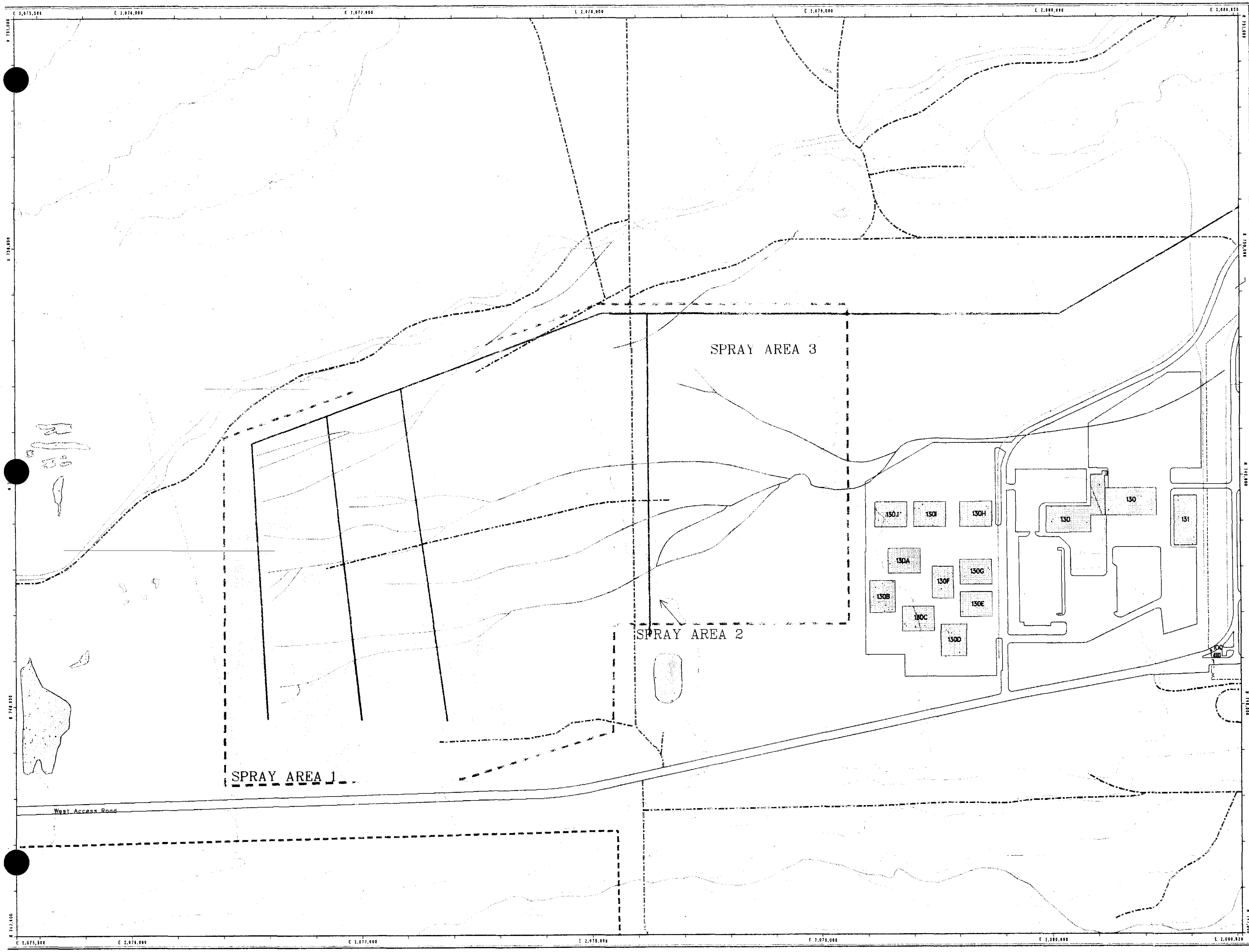
FOV = Field of View
m = meters
pCi/g = picoCuries per gram
µR/h = microRems per hour

FIGURE 3-3
1989 AERIAL GAMMA SURVEY ISOPLETH MAP OF OU 11 AND SURROUNDING AREAS

Area of 1993 HPGe Survey for OU 11,
The West Spray Field
Gamma Exposure Rate:
11-13$\mu R/h$



TERRESTRIAL GAMMA RAY EXPOSURE RATE AT 1 METER ABOVE TERRAIN EXTRACTED FROM THE GROSS COUNT RATE DATA



OU11/IHSS-168 Basemap
West Spray Field
Areas of Spray Application
Figure 1-1

EXPLANATION

- Spray Area
- IHSS 168 (OU11)
- Piping (Historical)
- Drainage Flow Line

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc. provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1991.
IHSS 168 is a proposed new area:
Pipes, Channels, and Spray areas are from aerial photo interp.

Scale = 1 : 4796.52
1 inch represents approximately 400 feet

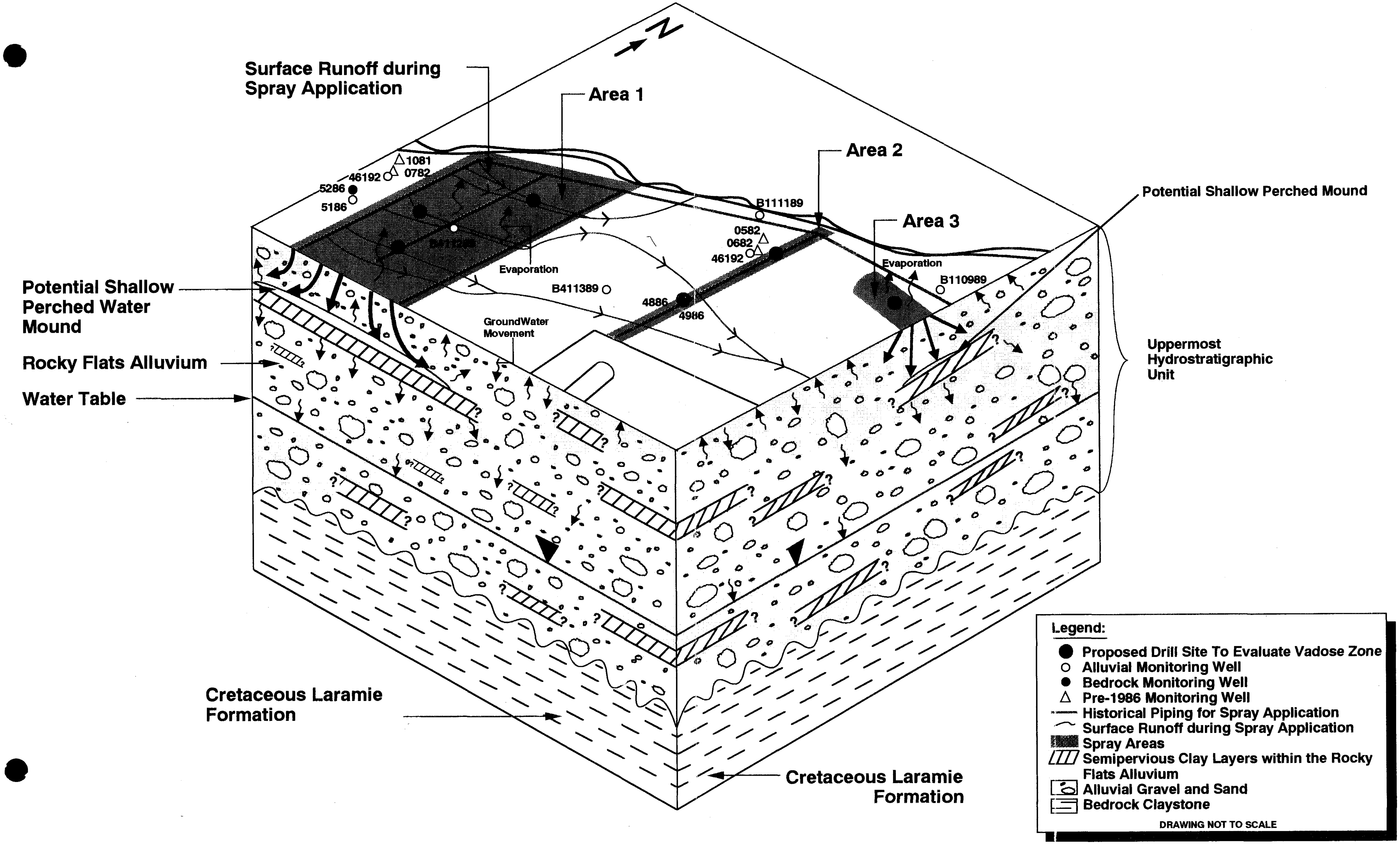
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

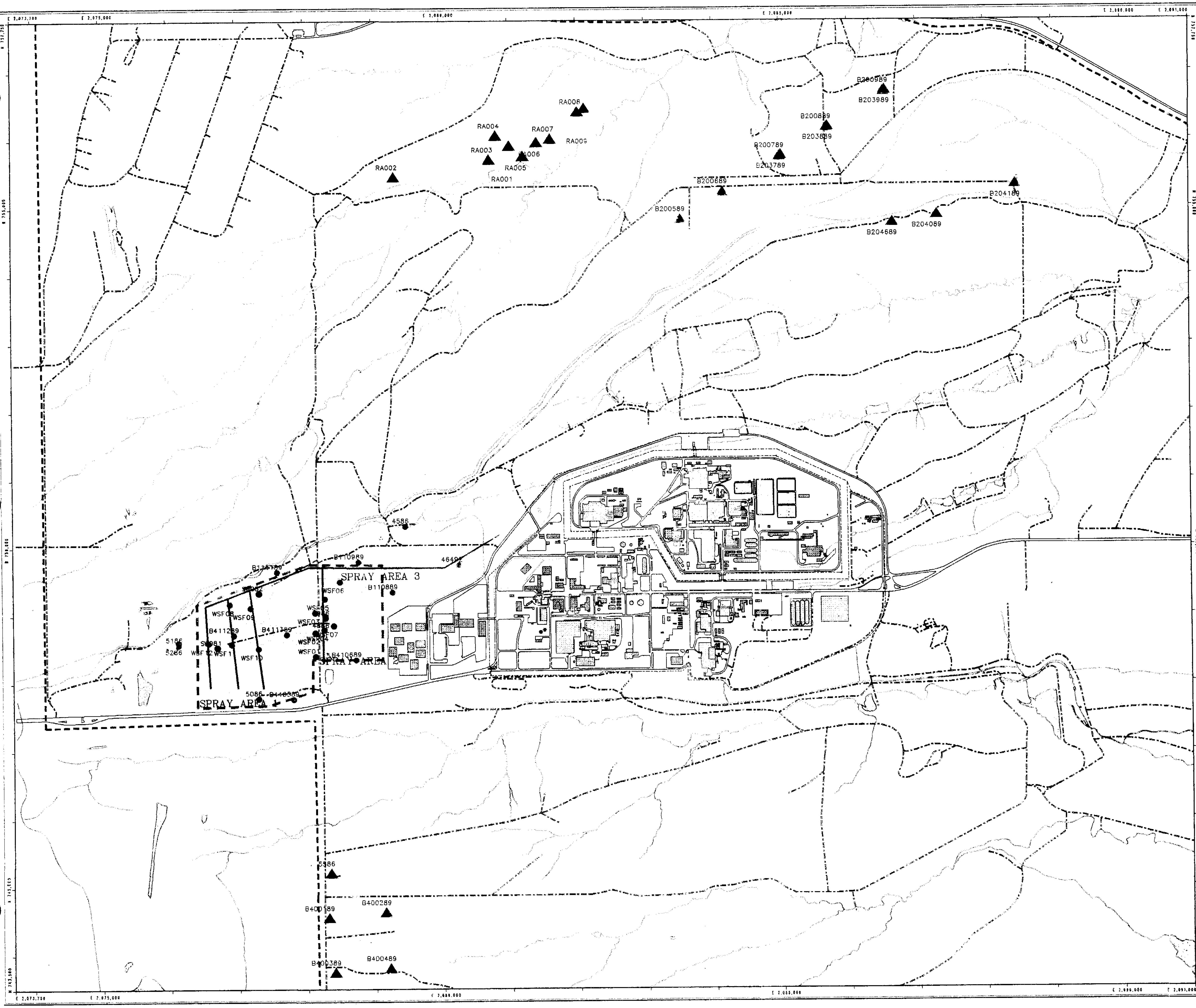
U.S. Department of Energy
Rocky Flats Plant

Prepared by:
EG&G ROCKY FLATS
Rocky Flats Plant
P.O. Box 464
Golden, Colorado 80402-0464

MAP ID: "Draft" June 02, 1994

Figure 2-1 Schematic Diagram of Conceptual Model – West Spray Field





OU11/IHSS-168 Basemap
West Spray Field
Sample Locations for Previous at OU11 and Background Locations

Figure 3-1

EXPLANATION

- Spray Area
- Approximate Area of 1986 Soil Sampling
- OU11 SW Locations
- OU11 Alluvial GW Locations
- OU11 Bedrock GW Locations
- OU11 Soils Locations
- Background Alluvial GW Locations
- Background Bedrock GW Locations
- Background Soils Locations
- IHSS 168 (OU11)
- Piping (Historical)

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fence
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1991.
IHSS 168 is a proposed new area:
Pipes, Channels, and Spray areas are from aerial photo interp.

N

Scale = 1 : 16823.09
1 inch represents approximately 1402 feet

500 0 1000 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Plant

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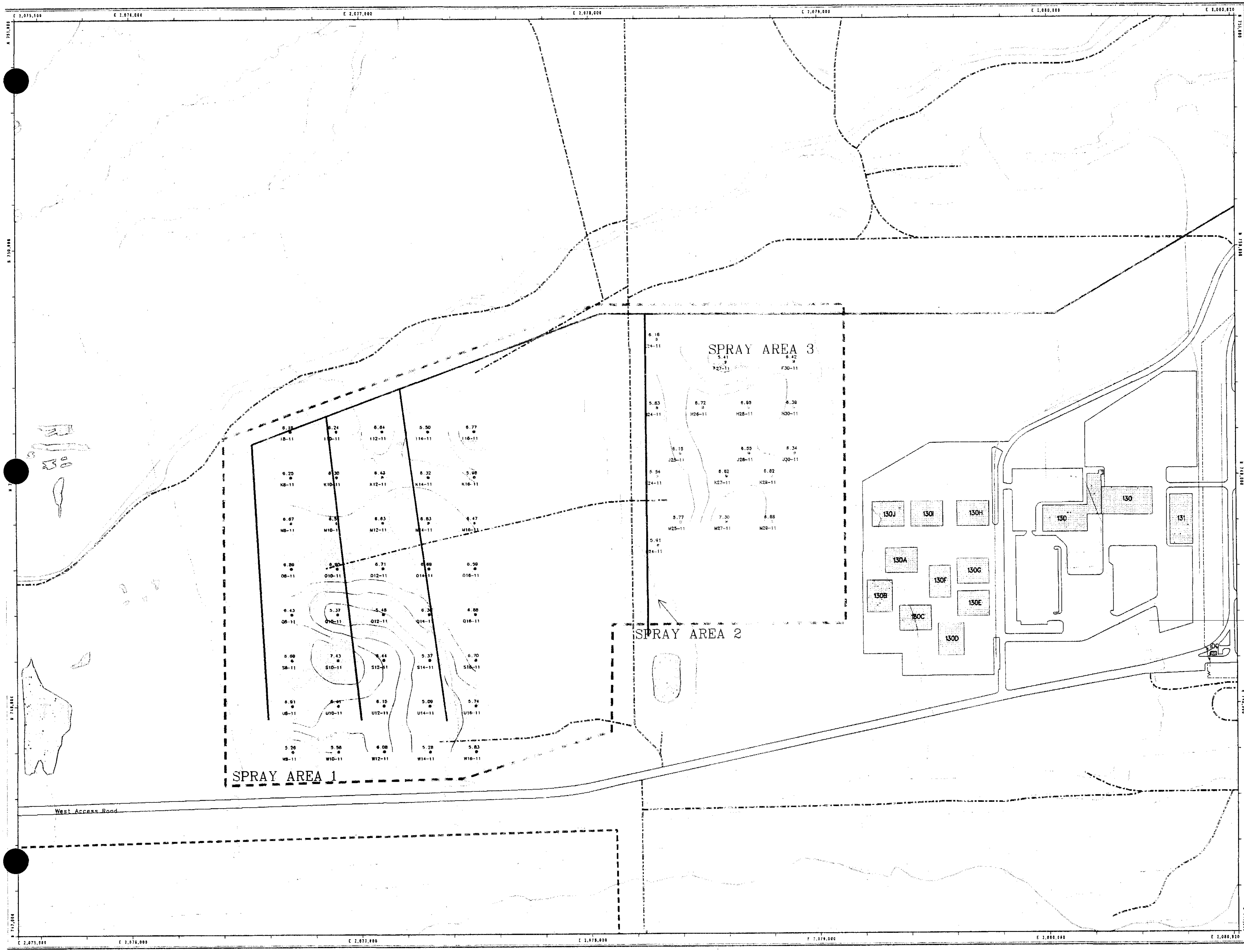
MAP ID: "Draft"

June 02, 1994



West Spray Field (OU11)
HPGE Data Sampling
Total Gamma Exposure Isopleth
Figure 3-4

EXPLANATION

Spray Area

6.72 Total Gamma Exposure (uR/h)

S8-11 HPGE Station Number

HPGE Location

IHSS 168 (OU11)

Piping (Historical)

Contour lines

Standard Map Features

Buildings or other structures

Lakes and ponds

Streams, ditches, or other drainage features

Fences

Contours (20' Intervals)

Rocky Flats boundary

Paved roads

Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc. provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1991.
IHSS 168 is a proposed new area.
Pipes, Channels, and Spray areas are from aerial photo interp.

Scale = 1 : 4796.52
1 inch represents approximately 400 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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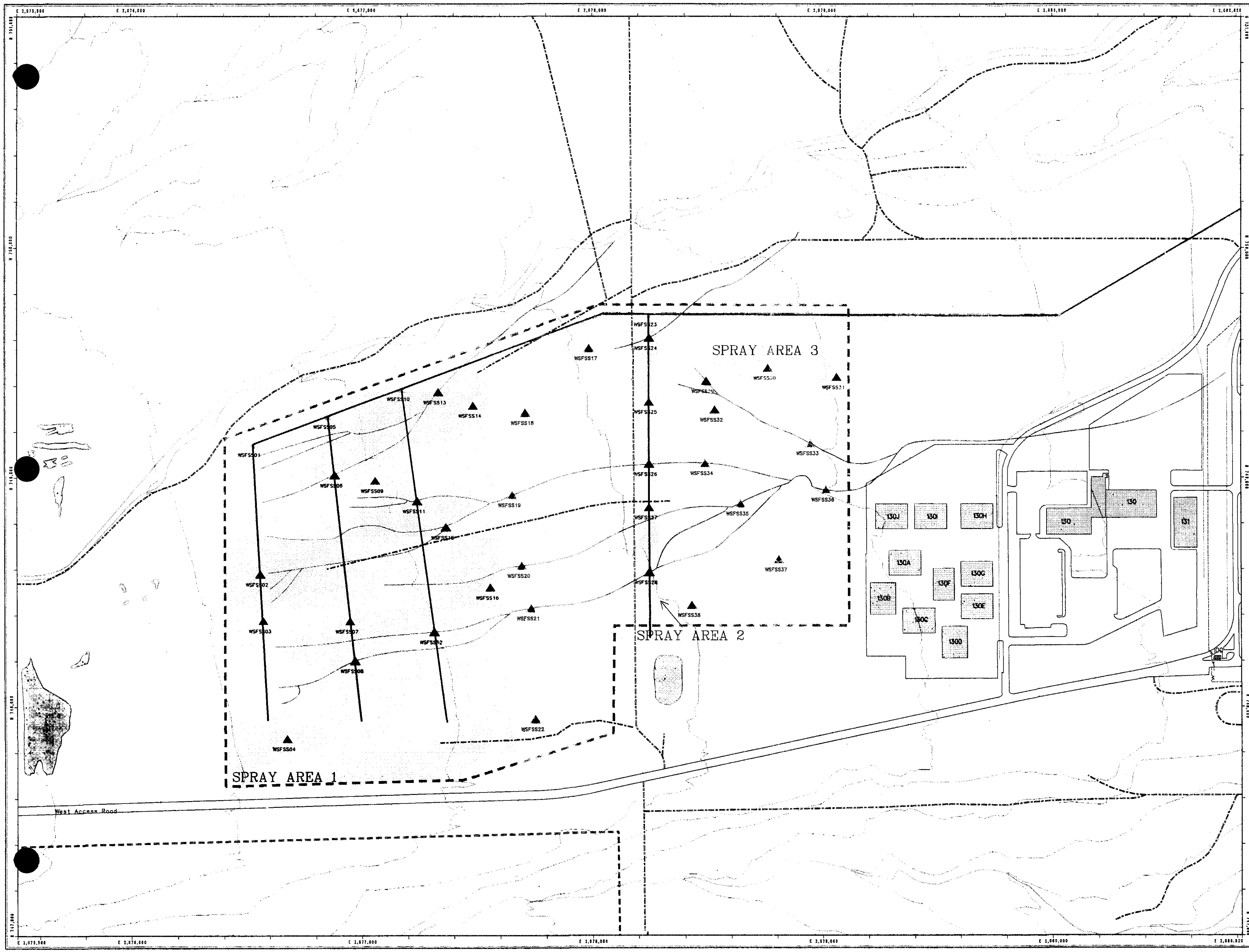

OU11/IHSS-168 Basemap
West Spray Field
Proposed Surface Soil Sample Locations
Figure 4-1

EXPLANATION

- Spray Area
- Spray and Channel (11)
- Non-Spray and Channel (7)
- Spray and Non-Channel (10)
- Non-Spray and Non-Channel (6)
- Pipeline Junctures (4)
- IHSS 168 (OU11)
- Piping (Historical)
- Drainage Flow Line

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc. provided by RedGlow Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1981.
IHSS 168 is a proposed new area.
Pipes, Channels, and Spray areas are from aerial photo interp.

Scale = 1 : 4788.52
1 inch represents approximately 400 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Plant

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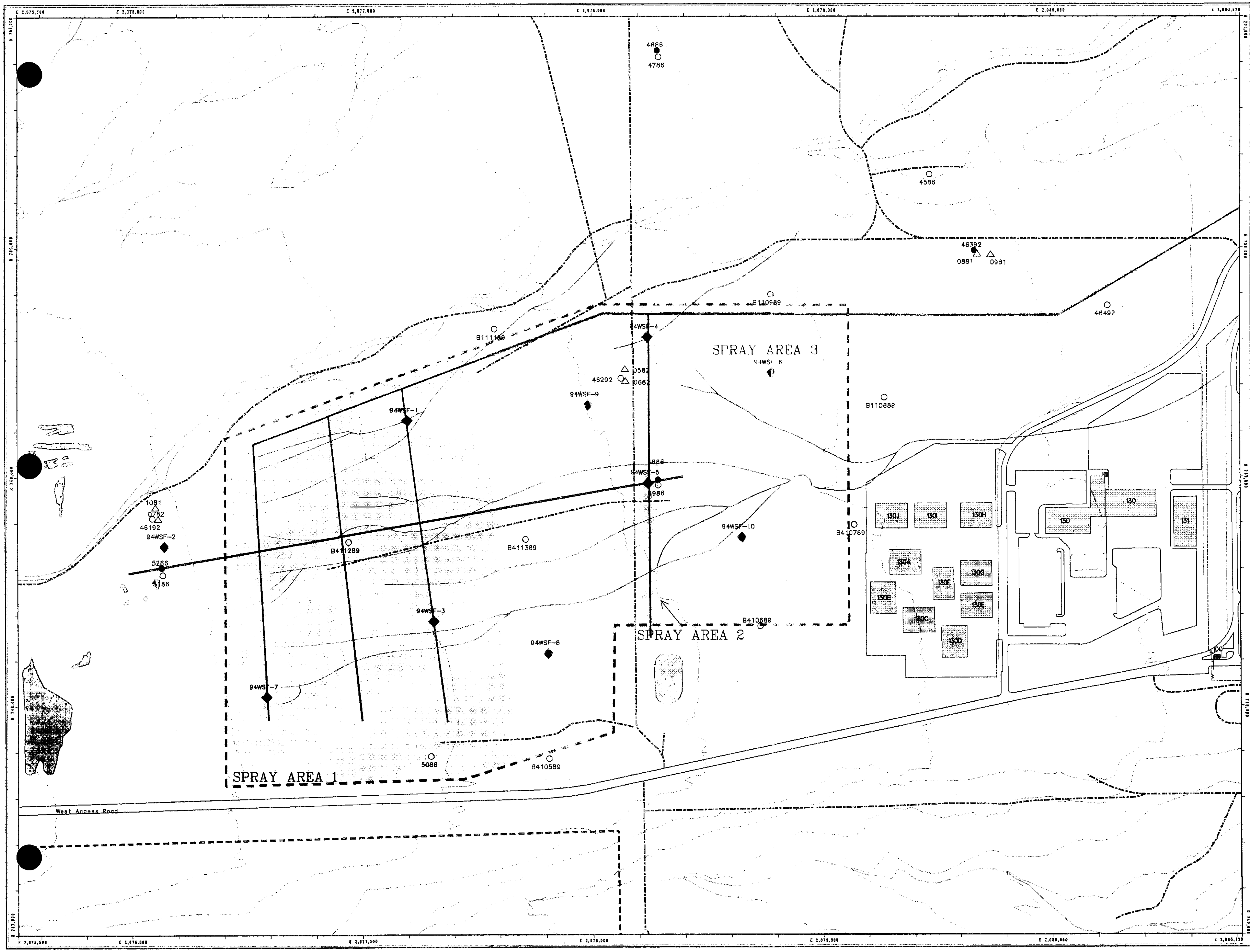
MAP ID: "Draft"

June 02, 1994



OU11/IHSS-168 Basemap
West Spray Field
Proposed Monitoring Well Locations
Figure 4-2

EXPLANATION

- Spray Area
- Proposed Monitoring Wells
- Pre-1986 Monitoring Wells
- Bedrock Monitoring Wells
- Alluvial Monitoring Wells
- IHSS 168 (OU11)
- Piping (Historical)
- Seismic Line
- Drainage Flow Line

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc. provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1991.
IHSS 168 is a proposed new area:
Pipes, Channels, and Spray areas are from aerial photo interp.

Scale = 1 : 4798.52
1 inch represents approximately 400 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Plant

Prepared by:
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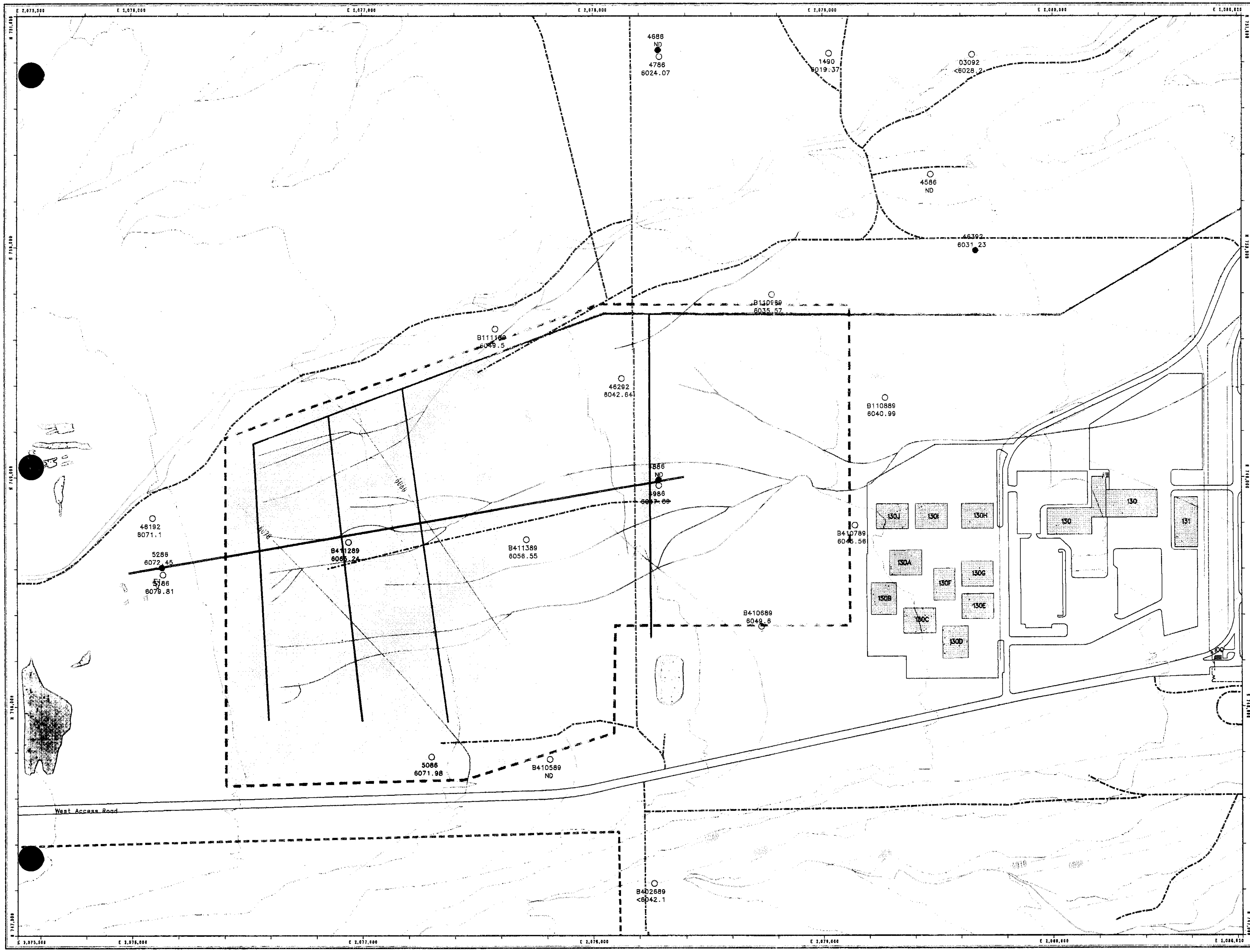
Golden, Colorado 80402-0464

MAP ID: *Draft*

June 02, 1994

OU11/IHSS-168 Basemap
West Spray Field
Groundwater Potentiometric-Surface Upper Hydrostratigraphic Unit
Fourth Quarter (October) 1993

Figure 4-4



EXPLANATION

- Spray Area
- Bedrock Monitoring Wells
- Alluvial Monitoring Wells
- IHSS 168 (OU11)
- Piping (Historical)
- Seismic Line
- Drainage Flow Line
- Groundwater Potentiometric contours, feet above MSL
- Approximate location of Potentiometric contours

Standard Map Features

- Buildings or other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences
- Contours (20' Intervals)
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE:
Map features buildings, road, fences, etc provided by Facilities Engr., EG&G Rocky Flats, Inc. - 1991.
Hydrology data for RFP is believed to be from USGS DLG data - 1991.
IHSS 168 is a proposed new area:
Pipes, Channels, and Spray areas are from aerial photo interp.

Scale = 1 : 4798.52
1 inch represents approximately 400 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Plant

Prepared by:
EG&G ROCKY FLATS
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Golden, Colorado 80402-0464

MAP ID: *Draft* June 02, 1994